APPLIED MECHANICS Reviews

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APPLIED MECHANICS REVIEWS

VOL. 11, NO. 10 MARTIN GOLAND *Editor* OCTOBER 1958

TWO-PHASE FLOW

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INTRODUCTION

The co-current flow of a liquid and a gas or vapor is of great practical interest in such applications as steam generators, boiling nuclear reactors, simultaneous flow of oil and gas in pipelines, film cooling of rocket motors. An extensive literature has appeared, particularly in the past ten years, on analytical and experimental attempts to explain the behavior of two-phase flow. Available correlations of data and analytical efforts have only succeeded so far in interpreting and predicting two-phase flow phenomena in limited areas. Some of the references, e.g. 8 and 20, duplicate several of the many graphs and equations resulting from these efforts. No such duplication will be made here; instead, a general picture of the present knowledge of two-phase flow will be attempted.

Because of the great difference in density and viscosity of the two fluids, the velocity of the gas phase is greater than the velocity of the liquid, giving rise to the so-called slip. The term quality (x), as commonly used for steam flowing in a pipe, is defined as the fraction by weight of vapor flowing through the pipe per unit time, namely,

$$x = \frac{V_g A_g/v_g}{V_g A_g/v_g + V_l A_l/v_l} = \frac{1}{1 + \frac{V_l}{V_g}\frac{v_g}{v_l}\frac{1-R_g}{R_g}} = \frac{1}{1 + \frac{V_l}{V_g}\frac{1-x_s}{x_s}} \quad [1]$$

where V_l and V_g denote the average liquid and gas (or vapor) velocities and v_l and v_g denote the specific volumes of each phase. A_g/A and A_l/A represent the fraction of the cross section of the pipe occupied by gas and liquid, respectively. A static quality x_s may be defined as the percentage vapor by mass in place, i.e.

$$x_s = \frac{A_g/v_g}{A_g/v_g + A_l/v_l}$$

As shown above, x_s equals x only if the velocities of the two phases are identical. It is often more convenient to use a volumetric quality (or void fraction) R_g defined as A_g/A and related to x and x_s by equation [1].

The volumetric fraction in place R_g gives a first indication of the arrangement of the two phases. These, however, may assume many geometrical patterns or flow regimes. Analyses of pressure drop and slip are based on a knowledge of these flow regimes, namely the kinematics of the problem.

FLOW REGIMES

Alves (1)* observed in a horizontal pipe the patterns shown in the figure. If a pipe has liquid flow in it and gas is added in increasing amounts, the following phenomena are observed. First the gas flows in small bubbles in the upper part of the tube. These grow in size (plug flow) until the liquid interphase becomes smooth and the gas moves much faster above it (stratified). Increasing the gas velocity, ripples appear at the interphase (wavy), which increase in amplitude and ultimately fill the pipe forming big slugs that move much faster than the rest of the liquid. A great increase in gas velocity will confine the liquid to an annulus and finally produce a fine spray of liquid in the gas when the flow quality is very large. As these changes take place the slip velocity increases and then decreases, being zero at both ends $x = 0$ and $x = 1$.

Baker (2) combined the observations made by several investigators on oil-gas and water-air mixtures in horizontal pipes. He succeeded in identifying the areas covered by each flow regime in a graph of gas flow rate against ratio of liquid to gas flow rates. The properties of the fluids in the different combinations were included in empirical correction factors.

In the case of a vertical pipe only symmetrical patterns are possible. Brancart (3) obtained correlations of flow regime areas in graphs involving the static volume fraction as abscissa and either liquid or gas flow rates as ordinates. The lines dividing the zones of flow regimes were almost vertical, showing that the geometrical proportion R_g is the most significant parameter determining the flow regime. For air-water mixtures, small bubbles exist only at very low volume fractions. When R_g is of the order of 5% the bubbles join into bullet-like plugs with small bubbles trailing in the wake. At about 40% by volume a bubble-liquid film covers the wall and gas flows much faster in the core (bubble-

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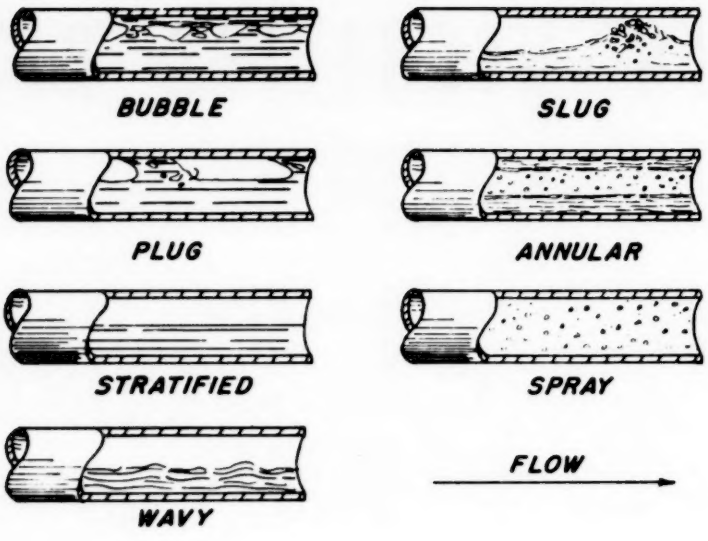
*Numbers in parenthesis refer to the bibliography.



annular). At R_g of 70 to 80% the bubbles in the film decrease significantly in size and the flow goes towards pure annular, e.g. an all-liquid film. High-speed films were taken of the flow after a boiling section (using Freon because of the lower saturation pressures). Vapor plugs were not observed and the number of small bubbles increased continuously, probably until about 40 or 50% static volume quality. At these gas concentrations it is believed that a gas core must appear (bubble-annular) (20).

As the total mass flow rate increases for a given static volume fraction the slip velocity decreases (4), (5). Analogously the "vertical" lines in Brancart's correlations shift toward the left as flow rates increase. Ultimately, at very high velocities, as encountered with critical flow conditions (seals in high-pressure pumps, capillaries in refrigerating units), the two-phase mixture behaves as a homogeneous fluid (6), (7). Homogeneous flow conditions are also approached when the properties of the two fluids are nearly equal, e.g. boiling near the critical pressure.

PRESSURE DROP IN ADIABATIC HORIZONTAL FLOW

Appreciable amounts of data are available on "friction factors" to predict the pressure drop for the adiabatic flow of two-phases in tubes and coils. The published data show a wide scatter, particularly when boiling is involved. Many of these efforts are reported in an excellent literature survey by Isbin, Moen and Mosher (8). Pursuing this method further, some authors have attempted to rationalize a two-phase "viscosity" that would permit the use of single-phase friction factor correlations. These efforts have generally met with little success when applied to wide ranges of flow conditions. This method enables however rough predictions of pressure drop, even when homogeneous flow conditions are used in the Fanning friction equation and the viscosity at all qualities is assumed to be the viscosity of the liquid phase.

The most successful correlation of two-phase flow pressure drops is that of Martinelli and collaborators (9), (10). Using data for various combinations of liquids and gases, he found that the isothermal pressure drop $(\Delta p/\Delta L)_{TP}$ was best nondimensionalized by dividing it by $(\Delta p/\Delta L)_g$. The latter is the pressure drop obtained if only the gas phase would flow inside the pipe; it can be calculated from known friction factors. The pressure drop parameter

$$\phi_g^2 = \frac{(\Delta p/\Delta L)_{TP}}{(\Delta p/\Delta L)_g},$$

as well as the void fraction R_g were found to be a function only of

$$X^2 = \frac{(\Delta p/\Delta L)_l}{(\Delta p/\Delta L)_g}$$

where $(\Delta p/\Delta L)_l$ is the pressure drop obtained if only the liquid phase would flow inside the pipe. He distinguished four curves to cover all the flow regimes, turbulent liquid and turbulent gas flow, laminar-laminar, laminar-turbulent and turbulent-laminar. The condition he assumed for laminar or turbulent flow of each phase was that Reynolds number be smaller or larger than 2000 when the phase flows alone in the pipe. Many experimenters have confirmed this correlation with dissimilar fluids, sometimes with minor modifications (8).

When extended to the case of wet steam, Martinelli (11) found that ϕ was not only a function of X but also of pressure, or ρ_g/ρ_l, and that his previous curves applied only at very low pressures, or when $\rho_g/\rho_l \approx 0$. At the critical pressure, $\rho_g/\rho_l = 1$, it can be shown that for the turbulent-turbulent case,

$$X^2 = (\phi_g^{1.11} - 1)^{1.8}$$

Most of the analyses of pressure drop in horizontal pipes have assumed an annular flow configuration with an all-liquid film and a smooth interphase. The most complete is the work of Levy (12) who considered the four cases of Martinelli assuming the seventh power velocity distribution in all cases of turbulent flow. He found good qualitative agreement between his analysis and the Martinelli curves but quantitatively his results were 20 to 40% below experimental data for $\rho_g/\rho_l \approx 0$. This discrepancy is probably due to the assumption of a smooth interphase. From Strawson's measurements of thin liquid films (13) it appears that the interphase must be wavy if the flow in the film is turbulent. For thin films McManus (14) measured with a conductivity probe that the amplitude of the waviness is of the same order of magnitude as the film thickness in annular flow.

PRESSURE DROP IN ADIABATIC VERTICAL FLOW

This pressure drop is often split in two terms, a friction pressure drop similar to that in horizontal flow and a gravity term. If the mixture is assumed homogeneous, i.e. no slip between the two phases, the last term becomes

$$\left(\frac{\Delta p}{\Delta L}\right)_{gr} = \rho = \frac{1}{v_l + x(v_g - v_l)} \qquad [2]$$

The true density of the mixture in the pipe is obtained if x in this expression is replaced by the static quality x_s as defined in the introduction. Many measurements have been made of the void fraction R_g and from it the velocity ratio V_l/V_g. With nonmiscible fluids, two quick shut-off valves operated simultaneously (2), (18), (19) give reliable results. With liquid and vapor of the same substance (e.g. wet steam), gamma-ray absorption techniques (15), (16), (18) can give not only an average static density but traverses result in density variation with radius. Bailey, Zmola et al (19) have used data of several investigators, as well as their own, to correlate successfully the void fraction R_g with a parameter

$$\frac{U_g - U_s}{U_l}$$

where $U_g = u_g v_g/A$ and $U_l = u_l v_l/A$, u being the mass flow rate and A the total pipe area. The apparent velocity U_s is the velocity of the gas phase U_g when $U_l = 0$, i.e. no net liquid flow. It can be correlated with R_g alone with very little influence of pipe diameter and fluid properties. The Bailey and Zmola paper also reports a void fraction distribution with radius that can be approximated by the expression

$$\frac{R_g}{R_{g_0}} = 1 - \left(\frac{r}{r_0}\right)^3 \qquad [3]$$

R_{g_0} being the void fraction at the center and r_0 the pipe radius, and this variation is apparently not influenced by fluid properties and flow conditions at low qualities (R_g less than 0.5 to 0.7).

Using the distribution of gas concentration given by equation [3], the writer (20) has attempted an analysis of the bubble flow regime. This analysis results in the simple expression

$$\frac{U_g - U_s}{U_l} = \frac{R_g}{K - R_g} \qquad [4]$$

where K is given as a function of fluid properties and flow conditions but is very little sensitive to both and is of the order of 0.9. Equation [4], as well as a more complex expression for U_s, agrees quite well with the experimental data of several investigators. The analysis can be extended to predict total pressure drop, i.e. friction and gravity terms combined.

The variation of gas concentration and mixture density with radius creates a secondary circulation in the flow. At low liquid flow rates this circulation may cause a down-flow of liquid near the wall, as observed experimentally (3). The existence of down-flow means that the shear stress at the wall, and therefore the "friction pressure drop," are both negative. This negative friction term could explain the difficulty encountered by several investigators in extending horizontal friction data to vertical pipes, particularly at the low flow rates and qualities encountered in natural circulation loops. It is in this low range that both this analysis and the Bailey and Zmola correlations are applicable.

At higher flow rates and qualities, measured values of slip and approximations of the friction pressure drop have yielded satisfactory results (16), (23), (24).

PRESSURE DROP IN FLOW WITH HEAT TRANSFER

If heat is added the quality changes along the pipe, linearly if the heat-transfer rate is uniform. In addition to the friction pressure drop in a horizontal pipe (friction plus gravity in a vertical pipe) there is a pressure drop due to the change in momentum of the fluid. The momentum term, between a section where $x = 0$ (all liquid) and a section with quality x, can be approximated by

$$\Delta p_m = \frac{G}{g} x v_g + \frac{G}{g}(1 - x) v_l - \frac{G}{g} v_l G$$

or

$$\Delta p_m = \frac{G^2}{g}\left[x^2 \frac{v_g}{R_g} + \frac{(1-x)^2}{1 - R_g} v_l - v_l\right] \qquad [5]$$

where G is the mass flow rate per unit area or mass velocity.

Martinelli (11) extended the application of his previous correlation to the boiling of water in horizontal pipes. He produced integrated curves of friction pressure drop between $x = 0$ and a quality x. With his correlation for R_g he evaluated the term within brackets in equation [5], which he called r_2. Leppert et al (21), boiling water in a horizontal pipe at low qualities, found that the Martinelli correlations gave pressure drops consistently about 15 to 20% lower than experiment. They attributed this to an error in the momentum term and evaluated it for a homogeneous fluid. If $V_g = V_l$, equation [5] simplifies to

$$\Delta p_m = \frac{xG^2}{g}(v_g - v_l) \qquad [6]$$

Leppert recognizes that at $x = 0$ the pressure drop is greater than the one evaluated for pure liquid because of the excess vapor present due to surface boiling. This effect becomes less significant at higher qualities, as indicated by the measurements of Egen, Dingee and Chastain (17). At 2000 psia Egen's data show that at qualities above 0.10, R_g greater than 40%, the effect of heat-transfer rate on R_g is negligible even for heat rates as high as 500,000 Btu/hr-sq ft. At low qualities the increase in R_g due to heat transfer is very likely the reason for Leppert's difficulties, as well as Weiss' (25), in evaluating the pressure drop in boiling from adiabatic data.

The formation of vapor bubbles at the wall very likely affects the flow patterns, particularly at low qualities, tending to even out the gas concentration across the pipe and reducing the secondary circulation. No visual observations of this have been made. Using gamma-ray techniques, Marchaterre (15) measured slip velocities along a boiling channel, in a natural circulation loop. He finds that the ratio of average phase velocities, V_g/V_l, reached a peak shortly after boiling started and remained constant thereafter in spite of quality changes. Measurements of slip velocities $V_g - V_l$ by Styrikovich and Kholodousky (26) are qualitatively in agreement with this observation. This also agrees roughly with equation [4] if K is unity (actually about 0.9 in most cases considered) and flow rates or qualities are high so that $U_s \ll U_g$. It would seem from this that no major changes in flow regimes occur while boiling takes place at moderate heat inputs. At very high heat inputs, on the other hand, a significant change of flow regime may occur when a film of pure vapor is formed near the wall, the condition known as burn-out.

Using the proper void fraction R_g, from measurement or analysis, to evaluate separately momentum and gravity terms leads generally to good predictions of flow rates in circula-

tion loops (16), (24). Because of other large losses (downcomers, separators, etc.) a rough approximation of the friction term is often sufficient.

CONCLUSIONS

The multiple uses of the co-current flow of two phases has produced a large number of isolated observations and analyses. An attempt has been made to interrelate them. Much needs to be done in this field, both analytically and experimentally, before a clear and general picture, as well as reliable predictions, can be made of the complex two-phase flow phenomena.

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Theoretical and Experimental Methods

(See also Revs. 3913, 3918, 3920, 3994, 4094, 4250, 4254, 4255, 4275, 4283)

Book—3861. Mickley, H. S., Sherwood, T. K., and Reed, C. E., Applied Mathematics in chemical engineering, 2nd ed., New York, McGraw-Hill (Series in chemical engineering), 1957, xii + 413. $9.

Book gives a good survey of the methods of applied mathematics with special emphasis to applications in chemical engineering. Reader's mathematical background is presumed to be limited. Text material begins with simple mathematical definitions and develops to more advanced procedures in a step-by-step manner. The headings of the ten chapters give a fairly good synopsis of the material covered:

1. Treatment of engineering data. (Graphical representation, interpolation, graphical and numerical differentiation and integration, 45 pp.)

2. Interpretation of engineering data. (Estimation of error, error function, analysis of variance, least squares, 59 pp.)

3. Mathematical formulation of the physical problem. (Setting up the differential equations from the physical laws, 29 pp.)

4. Solution of ordinary differential equations. (Special types of differential equations solvable, elementary, 29 pp.)

5. Series and numerical solutions of ordinary differential equations. (Power series solutions of linear differential equations of second order: Bessel functions, hypergeometric function, orthogonal polynomials, methods of Runge-Kutta, Milne and Euler, 41 pp.)

6. Formulation of partial differential equations. (Examples: equation of motion of a perfect fluid, equation for heat conduction, vectors, 48 pp.)

7. Solution of partial differential equations. (Separation of variables, orthogonal functions, Fourier series, 29 pp.)

8. The Laplace transforms. (Properties of transformation, table of Laplace transforms, 39 pp.)

9. Analysis of stagewise processes by the calculus of finite differences. (Series of batch reactions, extraction or leaching tanks and absorption and distillation columns in steady-state or unsteady-state operations, 20 pp.)

10. The numerical solution of partial differential equations. (Finite difference equations, graphical methods, relaxation methods, 59 pp.)

The problems are presented very clearly by many illustrative diagrams and a large number of concrete calculated examples drawn from practice. Moreover each chapter contains a list of references and several unsolved problems suitable for assignment. Differential equations and the methods of their solution are especially emphasized; not treated are nomography, instrumental methods, matrix calculus methods for solving algebraic equations and systems of linear equations, etc. Disregarding this fact the book is very good for students and those in the practice of chemical engineering. K. Gersten, Germany

3862. Saltzer, C., The theory of distributions, Advances in appl. Mech., **5,** (edited by Dryden, H. L., and von Karman, Th.), New York, Academic Press, 1958, pp. 91–110.

This manuscript represents a short excerpt (20 pp.) from Vol. V of the Advances in applied Mechanics. One of the central problems in analysis and its applications is that the process used in the solution of problems frequently leads to nonsensical results. The Laurent Schwartz's theory of distributions attacks these problems by generalizing the notion of a function, a derivative and

an integral giving a simple and direct calculus for the application of the method.

The main purpose of this chapter is to introduce the reader to the basic relations of this theory and their applications. The first two parts of the chapter treat the basic elements of this theory developed by the very general Mikushinski's method supporting the concept of continuity for weak functions defined by L. Schwartz. The next part treats the singularity functions (the Heaviside unit functions, the Dirac delta functions) and Hadamard's finite part of an integral. In the light of L. Schwartz's results about a weak derivative of a function, a heuristic approach is discussed also. Further, author considers the Fourier series and the Poisson transformation. It is shown that Fourier series whose coefficients are polynomials have meaning as weak functions. The concept of a weak function presents an immediate generalization of the theory of ordinary differential equations. This method is applied to Fourier transforms, and Fourier transforms of distributions are treated (the Parseval relation). The role of this theory in the generalized harmonic analysis, which is very useful to the engineer and physicist (the autocorrelation function), is explained. In the last part some applications are discussed—Green's function for the two-dimensional Laplace equation.

D. Raskovic, Yugoslavia

3863. Schroder, J., On the Newton method (in German), *Arch. rational Mech. Anal.* **1,** 2, 154–180, Sept. 1957.

General treatment of Newton's method in abstract spaces, not easily summarized in a few words. Convergence criteria and remainder formulas are obtained in terms of suitable norms, and application is made to the characteristic value problem. Generalizations of the method are made in several directions. Reference is made to previous papers by same author [*ZAMM* **34,** 241–255, 1954; *Math. Z.* **66,** 111–116, 1956; *Arch. Math.* **7,** 471–484, 1956] and to numerous works of others.

A. S. Householder, USA

3864. The distribution of a zone of stability in the plane of two coefficients of a characteristic equation on a subarea corresponding to possible combinations of active and complex roots (in Russian), Elementy teori rascheta giroskopicheskikh i navigatsionnykh priborov (MTVU, 48), Moscow, Oborongiz, 1955, 124–132; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 81.

An investigation is carried out of one of the methods of separation of zones with known combinations of real and complex roots of a polynome in the plane of two coefficients of the latter.

A. P. Duvakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3865. Williams, D. E., A note on some integrals in aerodynamics, *Aero. Res. Counc. Lond. curr. Pap.* 364, 10 pp., 1957.

Some double integrals in aerodynamics are difficult to evaluate because of the singularities in the range of integration. The Dirac delta function has been found useful in evaluating such integrals. Some examples of its use are given.

From author's summary

3866. Uhlmann, W., Error estimation in initial-value problems of ordinary differential equation systems of first order (in German), *ZAMM* **37,** 3/4, 88–111, Mar./Apr. 1957.

Error estimation formulas are derived for approximate solutions of a system of s ordinary differential equations of the first order for given initial values when the approximate solution has a continuous derivative. The formulas apply separately to each of the s approximate solutions. In Section 1 it is shown how the estimation formulas may be used directly for the Adams process and for the central difference method. From author's summary

3867. Pugachev, V. S., The use of canonical expansions of random functions in determining an optimum linear system (in Russian), *Automation and remote Control* **17,** 6, 545–556, 1957. [Translation of *Avtomatika i Telemekhanika.* Copies obtainable from Consultants Bureau, Inc., New York, N. Y.]

Paper develops the generalization of the theory of canonical expansions of random functions which was developed by the author; the theory of canonical expansions is used in order to find the general solution of the equation which determines the optimum linear dynamic system on the basis of the minimum mean-square error condition. From author's summary

3868. Luchak, G., The distribution of the time required to reduce to some preassigned level a single-channel queue characterized by a time-dependent Poisson-distributed arrival rate and a general class of holding times, *Operat. Res.* **5,** 2, 205–209, Apr. 1957.

The author determines the required distribution by seeking the distribution of busy periods. He begins by establishing the equations for a system with time-dependent Poisson arrivals which terminates when the last element in the queue has been served. Thus the probability that a queue is eliminated during time dt is $(d/dt)P_0(t)dt$; i.e., the distribution of busy periods is given by $(d/dt)P_0(t)$. This is extended to the title problem (queue reaches a preassigned level (a) by considering $P_n(t)$ as the probability that the queue has a length $a+n$ at time t. The method used is that defined in a previous paper [Luchak, G., *Operat. Res.* **4,** p. 711, 1956], and the notation of that more general paper is continued. E. Koenigsberg, USA

3869. Askovitz, S. I., Centroids, vectors, and least squares, *Amer. J. Phys.* **26,** 3, 164–168, Mar. 1958.

A mechanical model is presented which corresponds to the mathematical problem of determining the straight line best fitting a series of points according to the least-squares criterion. The model consists essentially of a bar in equilibrium under the action of suitable arranged springs. By applying certain relationships between centroids of points and vectors in equilibrium, two points can be located which determine the correct line. A graphic method can thereby be developed for drawing the line without any calculations. The technique is illustrated for the case of three points.

From author's summary

3870. Landau, H. G., High order accuracy in the solution of partial differential equations by resistor networks, *J. appl. Mech.* **25,** 1, 17–20, Mar. 1958.

Procedure is advanced enabling combined numerical and electric-resistor network solution of partial differential equations to a very high degree of accuracy—such as is needed, for example, if derivatives are to be calculated accurately from use of network-obtained quantities. Approximate solution of the partial differential equation is effected on the resistor network; the residuals in the corresponding finite-difference network are evaluated numerically; using these as current inputs to the nodes affords corrected values of the solution, such that if the errors in the original solution are of the order of a few per cent, the errors in the corrected solution will be of the order of a few hundreths of one per cent.

The procedure advanced is most easily applied to reducing the experimental errors, but it can also be used for reducing the lumping errors. Theoretical detail and use in practice are exemplified by solution of a problem of known analytic solution: determination of the stress function characterizing solution of the torsion problem for a cylinder of square cross section. Comparison of resistor-network and analytically determined values evidence the efficacy of the procedure for reducing both experimental and lumping errors: thus enabling solutions of a high degree of accuracy through use of resistor-networks whereof components and measure-

ments can be of less precision than would otherwise be necessary for the degree of accuracy desired.

T. J. Higgins, USA

3871. Fothergill, C. A., An improved blotter model for analog studies, *J. Petr. Technol.* **9,** 12, 55-56, Dec. 1957.

A simply-constructed easily-used blotter model for self or class (by use of projector) demonstration of the flood patterns to be expected from various arrangements of input and output wells in waterflooding projects is described in detail. In particular, use of easily arranged drawing pins, representing the input wells, pressed through the plastic sheet which carries the blotting paper representing the field, obviates the obscuring suspended cathodes and connecting wires used in earlier blotter models.

T. J. Higgins, USA

3872. Ip, S. K., An electrolytic tank as an analogue computing machine for factorizing high degree polynomials, *Quart. J. Mech. appl. Math.* **10,** 3, 369-384, Aug. 1957.

Concise account is given of the basic theory underlying determination of the zeros of a polynomial through Lucas' procedure of exploration of the potential distribution set-up by point electrodes in a uniform sheet of conducting material. Construction of a shallow single-layer circular electrolytic tank wherein the upper-half of a complex z-plane is represented on its surface through use of the transformation $\zeta = -1/(z + i)$ is described; the theory pertinent to finding with it the real and complex zeros of a polynomial is detailed; and use in practice is exemplified by determination of the zeros of an 8-th and a 16-th order polynomial to an over-all accuracy of "about 4%."

General discussions of accuracy, pertinent advantages, and certain ideal techniques in use buttress the foregoing account. The paper is clearly written; the content is easily grasped; the procedure advanced is of general applicability in the analysis and synthesis of electric and mechanical filter circuits, automatic control systems, and kindred areas. T. J. Higgins, USA

3873. Kovasznay, L. S. G., An electronic analogue for supersonic flow, *J. Fluid Mech.* **2,** 4, 383-396, June 1957.

Concise account is given of pertinent features of the method of characteristics as apposite to two-dimensional flows, that are hyperbolic everywhere, as in steady uni . . and linearized supersonic flow. In the proposed analog solution the characteristic lines are generated by electronic scanning of the screen of a cathode-ray tube, the boundary conditions being introduced through use of an opaque mask, and the desired solution appears on the screen of a second cathode-ray tube. Particular interest attaches to the fact that nonlinear behavior, to a certain extent, is easily introduced—say by changing one of the scan velocities. Basic analysis of second-order flow, complementary account of the analog system, and details of the experimental set-up are supported by complementing figures and several plates illustrative of the detail obtainable with the analog.

This well-written paper can be read with interest and profit by all interested in either flow theory or in analog solution in general. T. J. Higgins, USA

3874. Malavard, L. C., Recent developments in the method of the rheoelectric analogy applied to aerodynamics, *J. aero. Sci.* **24,** 5, 321-331, May 1957.

Paper comprises account of use of rheoelectric analog methods (by use of electrolytic tank or conducting paper) in various aerodynamic studies effected in France at CNRS and ONERA during the last several years. In particular, account is given of their use in: the direct plotting of velocity fields (as applied to the plotting of isobars around cascaded or flapped airfoil sections, determination of jet lines, tracing lines of constant modulus in conformal mapping, and in the representation of infinite field extent by double tanks); the study of lifting surfaces (with particular reference to a straight-line airfoil under various conjoined actions of blowing, flap setting, and jet ejection); and the study of the annular wing (investigation of aerodynamic properties as affected by change in camber, thickness, conicity and incidence). This interestingly detailed paper can be read with profit by all aerodynamicists and by anyone interested in electroanalogic methods.

T. J. Higgins, USA

3875. Cowley, P. E. A., The application of an analog computer to the measurement of process dynamics, *Trans. ASME* **79,** 4, 823-832, May 1957.

If a sinusoidal input is applied to a process system the steady-state output may, in general, comprise a sinusoidal component of the same frequency plus higher harmonics (due generally to nonlinearities in the process) plus miscellaneous obscuring signals termed noise. The latter two aspects may so mask the fundamental sinusoidal component as to render undiscernible direct observation of its phase shift and amplitude ratio relative to the sinusoidal input—thus, obviate direct determination of the "frequency response" of the system. In such case the desired phase shift and amplitude ratio may be calculated from certain correlations between input and output signals as effected with an analog computer or a digital computer. The basic theory underlying such calculation is advanced; two correlation procedures, the quadrature-components and the phase-null methods, are advanced. The use in practice and relative efficacy of each is illustrated by application to a process system analoged of cascaded resistor-capacitor networks and to an actual exothermic temperature process, to the end that, in each case, determination of frequency response is possible over a much more extended range of frequency than is possible for direct (visual) observation. The relative advantages and disadvantages of correlation techniques are stated, and the merits of analog and of digital correlation remarked.

This clearly written paper, with context illustrated by numerous circuit diagrams and graphs, should be of value to all interested in process dynamics. T. J. Higgins, USA

3876. Kozlov, E. S., and Nikolaev, N. S., The approximate solution of partial differential equations via electrical models (in Russian), *Automation and remote Control (USSR)* **17,** 10, 993-999, Oct. 1956. (Translation of *Avtomatika i Telemekhanika* **17,** 10, 890-896. Copies obtainable from Consultants' Bureau, Inc., New York, N. Y.)

Primarily, paper comprises description of various well-known techniques for electric-resistor-network solution of boundary-value problems characterized by Laplace, Fourier, or Poisson-type partial differential equations. The item which renders the paper of particular interest is description and circuit diagrams of means of supplying time-varying boundary values by utilizing outputs of function transformers carried in channels to the boundary, these channels programmed in time by a special electronic pulse source, a time-sequence controller comprised of an assembly of trigger circuits. Brief note is given of an automatic unit which rapidly locates and records isolines of the quantity of interest.

T. J. Higgins, USA

3877. Lees, S., Interpreting dynamic measurements of physical systems. I Aims and objectives; II Methods for testing physical systems and for interpreting dynamic measurements, *Trans ASME* **80,** 4, 833-857, May 1958.

Paper offers a general discussion of experiments and their interpretations. Part I discusses criteria for selecting a test method, with some analytic presentation of the "multicoupled operating system." Part II classifies all testing and interpretation of physical system into six categories: (1) Derivatives method. (2) Steady-state frequency method. (3) Standard curves method. (4) Indirect

frequency method. (5) Random input method. (6) Combination method. The basic analytical procedure and techniques and limitations of each method are discussed.

Y. C. Fung, USA

3878. Staff of the Lewis Laboratory, Central automatic data processing system, *NACA TN* 4212, 37 pp. + 11 figs., Apr. 1958.

A centralized system has been developed and installed for the automatic recording and processing of data from several remotely located testing stations. Pressures, voltages, frequencies, and other pertinent variables are recorded on magnetic tape in digital form. The magnetic tape is fed into a high-speed digital computer to convert raw data to dimensioned quantities and to compute any terminal calculations called for by the test engineer. Computed data can be returned to the test engineer the next day; raw data can be returned immediately. The system has been in operation for two years. From authors' summary

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 3894, 3895, 3896, 3946, 4045, 4118, 4131, 4184)

3879. Goodman, L. E., and Robinson, A. R., Effect of finite rotations on gyroscopic sensing devices, *J. appl. Mech.* **25,** 2, 210–213, June 1958.

When any line in a plane perpendicular to the spin axis of an otherwise freely supported gyroscope is caused to move so that it generates the surface of a cone then precession of the rotor occurs. This is due to the noncommutativity of three-dimensional finite rotations and results in drift of stabilized platforms. Conical motion may be induced by environmental vibration or undamped flight motions and the resulting behavior is a fundamental of gyroscopic phenomena and is not due to mechanical imperfections. Authors derive a general theorem pertaining to the kinetics of finite body rotations which they claim is new in the literature. This theorem clearly describes the mechanism of the drift, and authors use it to obtain the solution of a simple example.

C. D. Pengelley, USA

3880. Cannon, R. H., Jr., Kinematic drift of single-axis gyroscopes, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-72, 4 pp.

When any line in a plane perpendicular to the spin axis of an otherwise freely supported gyroscope is caused to move so that it generates the surface of a cone then precession of the rotor occurs. This results in so-called "kinetic drift" of gyro-stabilized platforms. Conical motion may be induced by environmental vibration or undamped flight motions, and the resulting behavior is a fundamental of gyroscopic phenomena and is not due to mechanical imperfections. Author manipulates basic gyro equations to provide expressions which permit quantitative evaluation of drift due to small conical vibratory inputs. Experimental and calculated data are shown to compare favorably for a laboratory model.

C. D. Pengelley, USA

3881. Pel'por, D. S., Movement of a gyroscope when the rotor axis approaches the axis of the exterior frame of the Cardan (universal) joint (in Russian), Elementary teorii i rascheta giroskopicheskikh i navigatsionnykh priborov (MTVU 48), Moscow, Oborongiz, 1955, 6–22; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 49.

The investigated movements have a value for gyroscopes used in aviation when the airplane is executing aerobatic maneuvres. Adopting the equation of movement, author studies the behavior of the gyroscope direction near Nester's pivot. For a free gyroscope the drawing nearer of the axes of the rotor and Cardan to the casing can be accompanied by very rapid rotation of the outer frame. Curves are given showing the character of the change of the angular velocity and the angular acceleration of the frame. Investigation is carried out, further, on the precessional movement of the gyroscope when the position of the axes of the rotor and Cardan is close to the casing. At the same time the effect is studied of friction on the bearings of the Cardan axis (moment of friction is proportional to the angular velocity). The author shows that the moment of friction in the axis of the outer frame and the moment of inertia of the frames might, under known conditions, bring both frames to the casing ("tightening" of the rotor axis) or bring about the opposite action ("pushing out" of the rotor axis). In both cases the moments indicated alter the position of the rotor axis of the gyroscope in space. Some ways for safeguarding the axes from coincidence are briefly looked into.

V. N. Skimel'

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3882. Ivin, S. M., Equations of the movement of the gyro vertical (in Russian), Mekhanika (MVTU 50), Moscow, Oborongiz, 1956, 261–271; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 48.

The gyro vertical is studied and differential equations of its movement, with correction for the forces of friction, are evolved. The equations take notice of the small oscillations of the gyroscope axis near the vertical. Theoretical results obtained conform closely to the experimental. V. N. Skimel'

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3883. Leitmann, G., A note on Goddard's problem, *Astronaut. Acta* **3,** 4, 237–240, 1957.

In a discussion of Goddard's problem of thrust optimization, it was shown that, in addition to an initial boost, a boost at burn-out may be required if both the altitude and velocity to be reached are specified. However, no account was taken of variation in burning time. In this note it is shown that such a variation must be considered for the case of second boost.

(See AMR **10** (1957), Rev. 582.) From author's summary

3884. Kao, S.-K., Stability of the motion of a rotating axial symmetrical solid body in a fluid, *Trans. Amer. geophys. Un.* **38,** 6, 831–834, Dec. 1957.

The stability criterion of the motion of an axial symmetrical solid body rotating about its axis of revolution and moving in the direction perpendicular to its axis of rotation is obtained. The major controlling factors which stabilize a rotating top in a fluid are examined. For a flat circular top the stabilizing effect of rotation appears less effective in the case of the rotating top translating in the direction perpendicular to the axis of rotation than parallel to the axis of rotation; the translation velocity destabilizes the rotating top in the former case but stabilizes it in the latter case. J. K. Yap, Holland

3885. Bodner, S. R., On the conservativeness of various distributed force systems, *J. aero. Sci.* **25,** 2, 132–133 (Readers' Forum), Feb. 1958.

3886. Vargo, L. G., Criteria for orbital entry, *Jet Propulsion* **28,** 1, p. 54, Jan. 1958.

3887. Ross, S., Minimality for problems in vertical and horizontal rocket flight, *Jet Propulsion* **28,** 1, p. 55, Jan. 1958.

3888. Khaimovich, A., Mechanics of the point of variable mass (in Russian), *Zh. matem. i. fiz. Akad. RNR* **3,** 28–34, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 30.

Equations are given of the movement of the point of variable mass for the case when mass m of the point depends on the time t, and the function of position $\varphi(x,y,z)$ movements are examined for particular cases of function φ. V. A. Sarychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3889. Vandakurov, Yu. V., One method of approximate solution of the problem of n bodies in natural coordinates (in Russian), *Byl. in-ta. teor. astron. Akad. Nauk SSSR* **6,** 4, 240–243, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 27.

A method of approximate integration of the equations of celestial mechanics is submitted, with the conditions that, for the disturbance function, the solution of the problem of two bodies is substituted, and that only the first stages of deviation are taken into account in the movement to the disturbed from the undisturbed state. The (novel) feature consists of the use of natural coordinates. G. A. Merman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3890. Carpenter, N., Some measurements of brake usage in a high-speed saloon car, *Instn. mech. Engrs., Auto. Div.* no. 9, 241–264, 1955/56.

3891. Webb, C. R., and Lavender, J. G., A comparative analysis of various methods of engine braking, *Instn. mech. Engrs., Auto. Div.* no. 8, 233–240, 1955/56.

3892. Sainsbury, J. H., Air suspension for road vehicles, Instn. Mech. Engrs. Auto. Div. Prepr., 12 pp.

3893. Coward, K. S., Dynamic similarity, *Aircr. Engng.* **29,** 345, 343–345, Nov. 1957.

Servomechanisms, Governors, Gyroscopics

(See also Revs. 3875, 3879, 3880, 3881, 3882, 4057, 4180, 4185)

3894. Guidance and control, Second guided missiles seminar, Venice, Italy, 1956; AGARD, Rep. 21, 24 papers, 321 pp. (Paperbound).

A collection of papers which on the whole touch lightly on various problems which might be encountered in design of guidance and control systems.

First two papers point out weapon system concept and interaction of guidance and control function with other sub-systems and with new inputs. Next three papers examine in general way various qualitative factors which determine system design, some possible guidance techniques, and an application of cross correlation theory to design of systems. Three short papers follow, dealing with elements of inertial and homing navigation systems. Two papers mention some control problems that may be encountered in system design and a summary paper gives general description of a three-axes stable platform.

Five expository papers treat general subjects of sampled data systems, digital techniques in missile design, and application of filter theory to guidance problems. There are four papers on the importance of reliability and four papers dealing with missile flight testing, ground testing, instrumentation, and data processing.

This series of papers is informative in a general way but offers nothing new, and in presenting a broad survey of guidance and control field reflects probable spirit of seminar.

L. Becker, USA

3895. Russell, W. T., Inertial guidance for rocket-propelled missiles, *Jet Propulsion* **28,** 1, 17–23, Jan. 1958.

The basic elements of inertial guidance systems primarily intended for rocket-propelled missiles are explained. Precision gyroscopes, accelerometers, and stabilized platforms are described. Guidance schemes appropriate to ballistic missiles are discussed, and a trajectory for the German V-2 rocket is presented as an example. The problem of gravity computation is considered and the effect of instrument errors is explored. A missile steering computer and a rocket motor shut-off computer are given for the V-2 rocket which is used as an example. Numerical values of coefficients are calculated for the sample trajectory.

From author's summary

3896. Duncan, D. B., Analysis of an inertial guidance system, *Jet Propulsion* **28,** 2, 111–115, Feb. 1958.

The characteristics of an inertial navigation system for a simplified guidance problem are described. Error equations relating component performance to guidance accuracy are derived. These equations exhibit the 84-min period oscillations which typify inertial systems. From author's summary

Vibrations, Balancing

(See also Revs. 4033, 4307)

Book—3897. Church, A. H., Mechanical vibrations, New York, John Wiley & Sons, Inc., 1957, xii + 275 pp. $6.75.

Book is intended for a concise introductory course for undergraduate students and for the training of engineers. Scope is not as advanced as Den Hartog's or Timoshenko's classical textbooks; topics such as nonlinear or self-excited vibrations are omitted. Contains many problems and examples, and is attractively printed. I. E. Garrick, USA

3898. Duffin, R. J., and Schild, A., On the change of natural frequencies induced by small constraints, *J. Math. Mech.* **6,** 6, 731–758, Nov. 1957.

By use of Hilbert space methods it is shown that (in a suitably normalized form) the increase $\delta\lambda$ in the square of the angular frequency of a given normal mode of vibration of an unconstrained linear mechanical system S due to the application of small constraints is given by $\delta\lambda = \delta V$; δV is the potential energy of S in the state of static deflection which would be produced by the action of the forces F whose amplitudes define the magnitude of the applied constraints. A formula is also given for the solution when the constrained system is a degenerate eigenvalue problem.

Method is applied in illustration to general vibrating string, membrane, and clamped-plate problems; it is shown that the lowest mode of vibration of a simply-connected clamped plate can have a nodal line, contrary to a conjecture of Szego [AMR **4,** (1951), Rev. 2420].

Reviewer considers that mathematical formulation of solution is in too general terms to be immediately useful to many engineers, but author refers to earlier paper which outlines applications of the theory [R. J. Duffin and A. Schild, Proc. Fifth symposium in applied mathematics, Amer. Math. Soc., 1954, 155–164].

G. D. S. McLellan, England

3899. Creech, M. D., The mobility of levers having uniformly distributed mass, *J. appl. Mech.* **24,** 3, 475–477, Sept. 1957.

The mobility (= velocity/force) method in the theory of mechanical and acoustical wave filters is applied to a lever with uniformly distributed mass and an arbitrary number of finite mobilities connected along its length. Dividing the mass into n equal mobilities,

the total mobility is given by an infinite-series expansion convergent to a finite value. H. Schaefer, Germany

3900. Anonymous, Oscillations of beams and plates of changing rigidity (in Russian), *Trudi Gruz. politekhn. in-ta* no. 4, 103–108, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2249.

Using Bubnov's method [*Sbornik in-ta inzhenerov putei soobshcheniya*, no. 31, 1913; "Selected Studies," Sudpromgiz, 1956] determinations are made of the frequencies of the transverse free oscillations of beams and plates of changing rigidity. The values of the frequency of the basic tone were found for different cases of fastening of the ends of the beam with changing rigidity, following previously selected principles. Values are given for frequencies of free oscillation in two cases of change of rigidity in a hinged rectangular plate. V. F. Karavanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3901. Anosov, A. S., The use of vector diagrams for calculating resonance vibrations of a beam under test for endurance (in Russian), *Trudi Leningr. politekhn.-in-ta* no. 3, 87–102, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1208.

In order to obtain data showing the nature of fatigue strength of constructions, investigations were made to test the large components of structures for endurance. The tests were carried out with a special machine, designed and erected in the Leningrad polytechnic institute. The test samples, in the shape of a welded beam of box section, were tested on a scheme of pure transverse bending (by means of hanging specially determined mass loads on their ends) evoked by a dynamic load in conditions of resonance, created with the help of mechanical pulsators. The stresses in the beam were ascertained by means of the amplitude of its oscillations, which depends very largely on the nearness to resonance. The scheme was looked into without resistance and in the presence of a viscous resistance on the loads, and also of friction of the loads upon the bar. Curves for resonance were plotted for the investigated system on the assumption that any type of resistance was absent, and also when friction forces were present.

B. K. Karapetyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3902. Florinskii, F. V., Precise and approximate solutions of some problems regarding the longitudinal oscillation of a load on an elastic bar (in Russian), *Trudi Dnepropetr. in-ta inzh. zh.-d. transp.* no. 25, 67–83, 1956; *Ref. Zh. Mekh.* no. 2, 1956; Rev. 2265.

An investigation is carried out on the longitudinal oscillation of an elastic bar with a load at its end, in different border conditions. Comparisons are made of the results of the precise solutions of the corresponding border solutions in mathematical physics and of the approximate solutions based on the examination of the system bar-load as a system with one step of freedom. It was established that good agreement is only obtained with small values of the parameter $\alpha = Fly/Q$ (F is the area of the transverse section of the bar, l and γ its length and specific gravity, Q is the weight of the load). Ya. S. Uflyand

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3903. Shimanskii, Yu. A., Vibration of plates in the external skin of ships near the screw propellors and measures for its correction (in Russian), *Sb. statei po sudostroeniyu, Leningrad, Sudpromgiz*, 1954, 49–52; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1127.

The note, first published in 1931, contains some practical recommendations based on a formula for the lowest natural frequency of a plate, rectangular in shape and freely open along its edges. V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3904. Meĭcer, S., Jr., and Holowenko, A. R., Dynamic characteristics of cam forms calculated by the digital computer, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-42, 7 pp.

One of the most important factors that influence cam-followers and their vibration is the cam contour. This paper presents a simple numerical method to obtain a concise representation of the dynamic characteristics that can be used as a "figure of merit" for various high-speed applications. The method presented is expressed in a form suitable for high-speed digital computation. The residual stress-factor curves for fifteen different cam forms are given. Included in the results are a number of cam contours for which exact mathematical analysis is intractable.

It is pointed out that the method of analysis presented in the paper may be used in more general problems concerned with the determination of the response of spring-mass systems to arbitrary excitation forces, including those involved in shock and impact studies. Reviewer believes that this paper is a notable contribution to the general theory of the vibrations of cam-and-follower systems. L. A. Pipes, USA

3905. Harris, S. L., Dynamic loads on the teeth of spur gears, Instn. mech. Engrs. Prepr., 16 pp., 1957.

In a theoretical analysis of a single pair of high-class gears three internal sources of vibration are considered: (1) Periodic variations in the velocity ratio due either to running the gears above or below the designed load, or to small manufacturing errors; (2) period variation in the tooth stiffness; (3) nonlinearity in tooth stiffness.

The amplitudes of vibrations caused by (1) depend on damping, while those caused by (2) or (3) will only occur if the damping is below a limit estimated at 0-.07 of critical damping. Damping currently reported for tests on steel gears is about 0-1 of critical, but might well be less.

Dynamic tooth forces and amplitudes of vibration were found from photoelastic stress patterns of model gears with both small and large errors. The more accurate gears showed only vibration caused by (1), variation in the velocity ratio, because the damping was too great for the other modes.

From author's summary by L. W. Hu, USA

3906. Pisarenko, G. S., Damped oscillations, under the action of forces, depending nonlinearly on the amplitude (in Russian), *Izv. Kievsk. politekhn. in-ta* **17,** 321–331, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1492.

An approximate investigation is made of the free damping oscillations of a system with one degree of freedom, described by an equation in the form of

$$\frac{d^2x}{dt^2} + p^2x + \epsilon\Phi(x) = 0$$

where p = const, ϵ small parameter, $\Phi(x)$ nonlinear function representing the force of resistance (of the hysteresis type) and satisfying the condition $|\epsilon\Phi(x)| \ll |p^2x|$. Account is taken of the fact that the principle of resistance might differ with an ascending (Φ_+) and descending (Φ_-) movement. The solution of equation (1) is in the form of $x = \alpha\cos(pt + \varphi)$ where α and φ are unknown functions, the determination of which by the known method leads to the solution of the equations

$$\frac{d\alpha}{dt} = -\frac{\epsilon}{p}\Phi[\alpha\cos(pt+\varphi)]\sin(pt+\varphi)$$

$$\frac{d\varphi}{dt} = -\frac{\epsilon}{\alpha p}\Phi[\alpha\cos(pt+\varphi)]\cos(pt+\varphi)$$

Regarding Φ, the hypothesis of N. N. Davidenkov on the dissipation of energy due to vibration is accepted [*Zh. tekh. Fiziki* **8**, 1938].

$$\epsilon\Phi_+(\alpha\cos\varphi) = -\frac{E\eta}{\alpha k}\,\alpha^k\,[(1+\cos\varphi)^k - 2^{k-1}]$$

$$\epsilon\Phi_-(\alpha\cos\varphi) = \frac{\epsilon\eta}{\alpha k}\,\alpha^k\,[(1-\cos\varphi)^k - 2^{k-1}]$$

where E, η, α, k are constants.

The author finds the solution of equation (1) in the first and second approximations following the method of N. M. Krylov and N. N. Bogolyubov. I. M. Volk

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3907. Alferova, N. V., Determination of the frequency and the relative amplitudes of a system with free torsional oscillations with the help of a mechanical model (in Russian), *Trudi Tsentr. n.-i. in-ta mor. flota* **1**, 2, 89–99, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1131.

A description of a mechanical model intended for investigation of torsion vibrations of shafting in a ship's assembly. The model represents in itself a collection of rods revolving in one plane and united one to the other by cylindrical springs. The moments of inertia of the rods and flexibility of the springs are selected by means of the given parameters of the system being investigated. The resonance of the model is produced by a crank-rocker mechanism. The frequency of the vibrations is determined by means of an indicator. The amplitudes of the vibrations are recorded on paper by the spark of a high-voltage inductor.

A. F. Minaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3908. Sawaragi, Y., and Fukuda, M., Model consideration on the early stage of fatigue of rubber vibration absorber, Proc. Sixth Japan nat. Congr. appl. mech., Univ. of Kyoto, Japan, Oct. 1956, 563–566.

By assuming that the fatigue phenomena in the early stage are mainly governed by the characteristic change (i.e., cutting and recombining) of the frictional mechanism, approximate equations were derived for the amplitude of a torsional moment with a number of repeated cycles, both for the continuous and interrupted driving of a rubber vibration absorber. E. G. Newman, USA

3909. Barkan, D. D., and Shekhter, O. Ya., Forced oscillations of a vibrator furnished with a sliding arresting device (in Russian), *Zh. tekh. Fiziki* **25**, 13, 2308–2312, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1501.

Together with the technical problem of sinking piles, pipes and so forth into the earth by means of vibration appliances, an investigation has been carried out on the influence of the oscillations of the implement being sunk on the oscillations of the movable part of the vibro-hammer and on the conditions of its construction. The construction under investigation is looked upon schematically as a system with two degrees of freedom.

V. O. Kononenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3910. Kryukov, K. A., Tabular method of calculating the critical angular speeds of multidisk rotors (in Russian), *Trudi Mosk. aviats. in-ta* no. 55, 5–62, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1226.

An investigation is made of the free and forced transverse vibrations of turbomachine rotor systems for different forms of precessional movements. An approximate tabular method of calculation is put forward to obtain the critical speeds of rotors working with a heterogenous distribution of mass and flexibilities on any number of rigid or elastic supports, with masses distributed between the supports and bracket. The action of the gyroscopic moments is taken into account. It is possible by the proposed method not only to determine the first critical speed, but also the critical speed of any order. Simultaneously with the natural frequency the form of oscillations is determined and also the diagram of the intersecting forces and deflection moments. The weight of the rotor is taken to be concentrated in several points. Such a scheme of calculation reflects sufficiently accurately actual systems in use for aviation gas turbines, turbo pump assemblies, and so forth, and permits, at the same time, a simplification to a significant extent of the calculations by comparison with the schemes with distributed parameters. The proposed method of calculation can also be used for computing the natural frequency of the wings of aeroplanes, propeller blades, vanes of turbines and compressors, and generally of any beam structure.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3911. Rosenberg, R. M., On the dynamical behavior of rotating shafts driven by universal (Hooke) couplings, *J. appl. Mech.* **25**, 1, 47–51, Mar. 1958.

Author investigates effect of Hooke-joint angularity on the bending stability during rotation of a light uniform elastic shaft carrying a heavy disk at its mid-point and supported at its ends by universal joints. If no torque is transmitted by the shaft, mild instability is predicted for driving speeds which are odd-integral submultiples of the fundamental critical speed of the system with zero joint angularity. When moderate torque is transmitted, new instabilities, which vanish at higher torques, are to be expected at speeds slightly less than all integral submultiples of the fundamental critical speed.

It is shown that the solution of the differential equations representing the system does not permit the case of zero torque to be deduced simply from that of non-zero torque.

S. Kirkby, England

3912. Downham, E., Theory of shaft whirling, Parts I, II, III, IV, V, *Engineer, Lond.* **204,** 5307, 518–522, Oct. 1957; **204,** 5308, 552–555, Oct. 1957; **204,** 5309, 588–591, Oct. 1957; **204,** 5310, 624–628, Nov. 1957; **204,** 5311, 660–665, Nov. 1957.

Paper reports series of theoretical and experimental studies on whirling of flexible shafts, with short rotors, carried out at the Royal Aircraft Establishment. Experiments are made with shafts of ¼-in. diameter and 12-in. length, rotating at up to about 5000 rpm, supported as cantilevers with an outrigger bearing of controllable stiffness. Effects of asymmetrical bearing stiffness, gyroscopic torque of rotor, lubrication, rotor unbalance, and bearing length and clearance are examined. Optical technique is used to record whirl patterns.

Paper contains numerous significant experimental results and comparisons with theory. For rotating system of considerable rotor inertia (gyroscopic torque effect), theory predicts measured critical speed with accuracy of better than ½%. For asymmetrical bearing stiffness, good agreement is found between theory and experiment, except for one unexplained (of four) observed critical speed. Bearing clearance effect is treated as nonlinear (polygonal stiffness function) spring. Lubrication is found to be significant in determining whirl amplitude at critical speed.

Reviewer feels that, although of generally good quality, paper suffers somewhat from lengthy derivations of relatively standard theory (presumably included for the sake of completeness) and emphasis (in first section) on errors by early investigators subsequently corrected by Jeffcott, which seems unnecessary since

the "incorrect" approach does not appear to be as prevalent nowadays as author claims. G. A. Nothmann, USA

Wave Motion in Solids, Impact

(See also Revs. 3902, 3905, 4009, 4030, 4109)

3913. White, J. E., Spherical waves coupled to a one-dimensional wave guide, *J. acoust. Soc. Amer.* **30,** 1, 65–68, Jan. 1958.

Author derives an approximate expression for the disturbance in a one-dimensional wave guide resulting from an expanding spherical wave loosely coupled to wave guide at all points along its length. Application is made to a slender rod immersed in a fluid in which axial strain is due to the fluid pressure wave through a Poisson's ratio coupling. Rod elementary theory is used, and strain wave response curves are presented for two different inputs and three ratios of fluid velocity to rod velocity. Velocity ratio is shown to have a strong effect on rod disturbance. J. Miklowitz, USA

3914. Abramson, H. N., Plass, H. J., and Ripperger, E. A., Stress wave propagation in rods and beams, Advances in applied mechanics (edited by Dryden, H. L., and von Karman, Th., **5,** New York, Academic Press, Inc., 1958, pp. 111–194.

A survey of the various approximative theories of propagation of tension, torsion, flexure, especially as developed in relation to oscillograph recording in recent years. Chapter is written, starting from elementary considerations, with regard to previous surveys, emphasizing coordination of experimental and analytical results rather than methods. Phenomena are classed as elastic, plastic, viscoelastic. J. N. Goodier, USA

3915. Thomas, T. Y., The decay of waves in elastic solids, *J. Math. Mech.* **6,** 6, 759–768, Nov. 1957.

Author considers propagation of wave surfaces of order one (having a discontinuity in spatial derivatives of displacement, but no discontinuity in displacement) in an infinite isotropic linearly elastic solid. Rigorous analysis leads to a simple expression for rate of decay of a measure of discontinuity strength, depending upon the mean curvature of the wave surface, for the two cases of irrotational and equivoluminal waves. Conclusion is that for decay the surface must be a developable surface (not a plane) or a surface of positive curvature. General results are illustrated by known results for plane waves (no decay) and spherical waves. The question of increase of wave strength, corresponding to situation with sonic waves in gases leading to a shock wave, is not considered because it requires displacement derivatives to grow beyond limits imposed by linear elasticity theory.
L. Malvern, USA

3916. Mochalov, S. D., Frequent impact at the end of a semi-infinite bar (in Russian), *Uch. zap. Tomskogo un-ta* no. 25, 68–76, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2273.

The problem is examined of the accumulation of residual deformations appearing in the bar under the action of repeated longitudinal impact blows. This problem was studied by Kh. A. Rakhmatulin [*Prikl. Mat. Mekh.* **10,** no. 3, 1946; **14,** no. 1, 1950] with some limitations imposed on the relation between the stress and the deformation. The author affirms that the given problem has been solved by him with assumptions different from Rakhmatulin's assumptions, but that the results do not differ from those obtained by Rakhmatulin. No investigation is made of the spreading of the longitudinal waves in the bar. The author only qualifies his findings by a reference to his own work [*Ucb. zap. Tomskogo un-ta* no. 25, 1955]. No comparative analysis of the assumptions adopted in this article and Rakhmatulin's assumptions is furnished. N. A. Kil'chevskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3917. Cristescu, N., Propagation of plastic waves in steel rods (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 191–202.

Theoretical paper deals with plastic waves in work-hardening material, where, in the region beyond the yield point, the stress-strain curve is concave against the stress axis. Author considers a semi-infinite bar, initially at rest, and with dynamic boundary conditions prescribed at the end. The strain here is represented by a polynomial in time, in the simplest case by linear function. It is shown that even when there is no discontinuity in the imposed conditions plastic shock waves can build up further down the bar, by virtue of the assumed stress-strain relation.
F. C. Roesler, England

3918. Hanin, M., Propagation of plane disturbances in an elastic, viscous medium (in English), 9th Congrès intern. Mécanique appl., Univ. Bruxelles, 1957; **3,** 196–204.

This is a mathematical paper concerned with solving the equation $(\nu\partial^3 U/\partial x^2\partial t) + c^2(\partial^2 U/\partial x^2) - (\partial^2 U/\partial t^2) = 0$. If U is a local velocity, c the velocity of sound, and ν the kinematic viscosity, this equation describes the propagation of waves in compressible viscous fluids or in certain elastic solids with viscous properties. Solutions are obtained which correspond to a sharp initial pulse, represented by a delta function of the time. Solutions are obtained in analytical form giving insight into the initial and also into the asymptotic behavior of the solutions. Results are illustrated by graphs showing that the main effect of viscosity consists in broadening the original pulse.

It is nowhere indicated to which physical or engineering problem the solutions are to be applied. R. Eisenschitz, England

Elasticity Theory

(See also Revs. 3941, 3946, 3958, 4008, 4252, 4319, 4320)

3919. Ignaczak, J., Thermal stresses in a long cylinder heated in a discontinuous manner over the lateral surface (in English), *Arch. Mech. stos.* **10,** 1, 25–34, 1958.

The temperature of the lateral surface of an infinitely long cylinder is determined by Heaviside's step function z. Expressing the temperature of the interior of the cylinder by means of a double Fourier-Bessel integral, author represents the stress tensor as a sum of three tensors, the first corresponding to the thermoelastic potential, the second and the third to Love's stresses. The author succeeds in expressing the results in the form of simple integrals.
M. Sokolowski, Poland

3920. Geertsma, J., A remark on the analogy between thermoelasticity and the elasticity of saturated porous media, *J. Mech. Phys. Solids* **6,** 1, 13–16, 1957.

Author in this brief note considers the strict analogy between a certain temperature distribution equation of thermoelasticity and the complete pore pressure distribution for a saturated porous medium. A reference is given to the work of Lessen on the thermoelastic temperature distribution equation which contains a mechanical interaction term. References are also given for Biot's study of the thermoelastic equation as well as the equation for the pressure distribution in the porous medium.

The paper contains a comment on the measurability of the physical constants for the case of the porous medium. Reviewer is still skeptical with regard to the experimental determination of the

constants, especially when compressibility of the liquid is taken into account. W. H. Hoppmann, II, USA

3921. Nowacki, W., The state of stress in an elastic space due to a source of heat varying with time in a harmonic manner (in Polish), *Rozprawy Inz.* **5**, 3, 511–521, 1957.

Three types of heat sources are considered: point, linear and surface sources, acting in an elastic space with a harmonically variable output. The problems are solved by means of the thermoelastic potential in the complex form and the Fourier exponential transformation. The diagrams presented show the dependence on time of the stresses in the elastic body.

M. Sokolowski, Poland

3922. Nowacki, W., A quasi-steady-state three-dimensional thermoelastic problem (in Polish), *Rozprawy Inz.* **5**, 3, 499–509, 1957.

The problem of an elastic semi-space on the surface of which a source of heat moves with a constant velocity is obtained by considering the full space, with a dipole source moving inside. By using moving coordinates, the problem becomes stationary and can be solved in the known manner by introducing the thermoelastic potential in the form of Fourier integrals. The transition to the semi-space is done by attaching to the plane normal to the dipole axis additional external stresses, enabling the satisfaction of the conditions of free boundary. The solution of an analogous two-dimensional problem is also presented.

M. Sokolowski, Poland

3923. Nowacki, W., A steady-state three-dimensional thermoelastic problem (in Polish), *Rozprawy Inz.* **5**, 3, 487–497, 1957.

The state of stress in an elastic semi-space, subjected on its boundary to a temperature $T(x,y)$, is determined in two stages. In the first stage the state corresponding to the temperature represented by Dirac's function is determined; in the second, the integration is carried out.

For the determination of Green's function, the thermoelastic potential and a complementary Galerkin function are used in the form of Fourier-type integrals. It is found that the stresses with vectors directed normally to the bounding plane disappear in the entire semi-space. M. Sokolowski, Poland

3924. Nowacki, W., Two steady-state thermoelastic problems (in English), *Arch. Mech. stos.* **9**, 5, 579–592, 1957.

In the first problem the author determines the state of stress produced in an infinite elastic space and semispace by a temperature field determined by the heat equation and the boundary conditions of T vanishing at infinity, while inside a circle of radius $r = a$ in the $z = 0$ plane (in cylindrical coordinates) the heat flow remains steady and equal to Q. No heat flow exists in the $z = 0$ plane outside that circle. The heat equation with the above boundary conditions has a solution in the integral form given by H. S. Carslaw and J. C. Jaeger.

In order to find the state of stress the author uses the potential of thermoelastic displacement Φ (according to E. Melan) from which the Cartesian displacement components u, v, w are obtained by differentiation.

The function Φ satisfies Poisson's equation. Knowing this function author can obtain directly the stress in the form of functions containing Gaussian hypergeometric series.

To obtain the solution of this equation for an elastic semispace author seeks a solution, connected with the preceding, that would cancel the stresses obtained before. For this purpose he determines Love's function satisfying the biharmonic equation. The components of the latter state of stress follow directly from the general integral form of the function ϕ. Adding the two solutions author obtains a series whose terms contain hypergeometric series and change in the $z = 0$ plane into elliptic integrals of both kinds. The stresses σ_{zz} and σ_{rz} vanish in the entire semispace.

The stresses σ_{xz}, σ_{yz}, σ_{zz} vanish also in the more general case where the heat flow is constant in any region Γ of the $z = 0$ plane and if the flow vanishes over the entire remaining part of the $z = 0$ plane. To prove this the author solves the additional problem of determining the Green's function for heat flow. The stresses thus obtained do not satisfy one of the boundary conditions, because $\sigma^*_{zz} \neq 0$. Therefore the author solves additional problems in which there exists only one stress different from zero in the $z = 0$ plane, that is $\bar{\sigma}^*_{zz} = \bar{\sigma}_{zz}$. For this purpose the Galerkin displacement function for isothermal states is used. This function should satisfy the homogeneous biharmonic equation. It is chosen as a Fourier integral. Adding the stress system thus obtained to the above the final solution $\sigma^*_{zz} = \bar{\sigma}^*_{zz} + \bar{\bar{\sigma}}^*_{zz}$ is obtained in a closed form, relatively simple, where the stresses σ^*_{zz}, σ^*_{xz} and σ^*_{yz} vanish in the entire elastic semispace.

The second problem solved in the paper reviewed consists in the assumption that the temperature inside a circle of radius a in the $z = 0$ plane remains constant and equal to $T = V = \text{const}$, and outside that circle, that is for $r > a$ and $z = 0$, we have always $\partial T/\partial z = 0$ and $T = 0$ at infinity. The author obtains immediately the solution, in which $\sigma_{r\varphi} = \sigma_{rz} = \sigma_{zz} = 0$. Also in this involved case of discontinuous thermal boundary conditions three stress components are equal to zero. Finally the author generalizes the solution to cases where the temperature is constant inside any region Γ of the $z = 0$ plane.

The theorem of vanishing of the three stress components remains valid in the case of a layer (plate) unbounded in the x and y direction and having a finite thickness b in the z direction if the corresponding thermal boundary conditions are satisfied on one or both bounding planes. J. Naleszkiewicz, Poland

3925. Slobodyanskii, M. G., Two-sided approach in some problems in the theory of elasticity and [the] potential theory (in Russian), *Trudî Mosk. energ. in-ta* no. 17, 122–141, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2135.

3926. Shakhaidarova, P., Formulas for the experimental determination of the stresses on the surface of an anisotropic elastic body (in Russian), *Trudî. in-ta matem. i. mekhan. Akad. Nauk UzSSR* no. 13, 103–110, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2137.

An extension of the work of A. S. Arzhanykh on the isotropic elastic body [*Izv. Akad. Nauk UzSSR* no. 5, 1952]. Formulas are obtained for an anisotropic elastic body, conforming to Guk's law, with the aid of which calculations can be effected of the surface stresses on the body, if the components of the migration of a given point on the surface being observed are measured. Cases are studied in which the elastic body is bounded by a plane surface, a cylindrical surface, and the surface of a sphere.

S. A. Ambartsumyan
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3927. Raymondi, C., Determination of the intrinsic deformation of a Saint-Venant solid loaded by a simple normal force (in Italian), *Pubbl. Fac. Ing., Univ. Pisa*, (16) Publication no. 48, 9 pp., 1956.

A detailed discussion is given of the classical problem of a prismatic cylinder of homogeneous, isotropic, elastic material loaded at each end by simple normal stress distributions, statically equivalent to a single force parallel to the cylinder's axis.

H. G. Hopkins, England

3928. Raymondi, C., Characteristics of the intrinsic deformation of Saint-Venant solids under pure flexure (in Italian), *Pubbl. Fac. Ing., Univ. Pisa,* (16a) Publication no. 49, 13 pp., 1956.

A detailed discussion is given of the classical problem of a prismatic cylinder of homogeneous, isotropic, elastic material loaded at each end by simple normal stress distributions, statically equivalent to a pure couple about an axis normal to the cylinder's axis. H. G. Hopkins, England

3929. Kurdyumova, N. V., Problem of stress concentration at the ends of drawn-out insertions (in Russian), *Trudī Leningr. Korablestroit. in-ta* **16,** 38-49, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2151.

By applying Neiber's method ["Stress concentration," Moscow, Gostekhizdat, 1947], a solution is found for the problem of the drawing out of an infinite plate which has soldered to it an elliptically shaped piece which shows the presence of considerable stress concentration at the ends of the long piece.

A. Ya. Gorgidze
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3930. Bondin, V. F., Influence of local weakening (due to a central round opening) on the resistance of a wooden component to tension (in Russian), *Sb. nauch. rabot Belorus. politekhn. in-ta* no. 48, 74-85, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2531.

A description is given of experimental investigations of pine samples with tangential disposition of the annual growth layers in transverse section measuring 10 × 100 mm, length up to 1140 mm; length of the working part 400 mm. Moisture content of the wood was 11-15%, weight by volume 0.44-0.61 g/cm³. The transition from the end to the working parts was carried out with the help of recessing in the thickness (of the sample). The velocity of deformation in the test was 2 mm/min. The samples were weakened by means of a round hole with a diameter of from 5 to 60 mm. The experiments confirmed the previous findings of Yu. M. Ivanov and E. L. Rozen regarding the nature of the fracture with the formation of cracks tangential to the contour of the weakened portion. It was established that with a diameter increase of the hole from 5 to 50 mm, load P, corresponding to the formation of the first crack, is lowered by nearly 4 times and, in relation to the diameter d from 15 to 60 mm, may be expressed by the equation

$$P = \frac{946 \times 10^3}{d^2} + 1040$$

The characteristic of the resistance of the weakened component should be taken as the stress corresponding to this load, and not the intermittent resistance, as the value of the latter fluctuates within wide limits (the lowest value corresponds to load P). On the basis of the calculations for this load a calculation should be made for the boundary conditions and a determination made of the stress in wooden components with round holes under tension, introducing the coefficient for working conditions of from 1.00 to 0.43 with diameters of the holes commencing from 15 and up to 40% of the width of the component. Yu. M. Ivanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3931. Shimanskii, Yu. A., Influence of stress on the stability of elastic systems (in Russian), *Sb. statei po sudostroeniyu, Leningrad, Sudpromgiz,* 1954, 53-59; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 939.

A method is shown for the approximate calculation for the tangential modulus of elasticity for the subsequent determination of Karman's modulus. In the range of stresses $0 < \sigma < 2500$ kg/cm², an approximation of the bond between stress σ and deformation ϵ is assumed to have the aspect $\sigma = A + B^{\epsilon} + C^{\epsilon^3}$. Constants A, B, and C are found from the conditions: $\sigma = 0$ when $\epsilon = 0$, $d\sigma/d\epsilon = E_0$ wheff $\epsilon = 0$ and $\sigma = 2500$ kg/cm² when $\epsilon = 0.0015$. The last condition is adopted on the basis of experiments on twenty test pieces of steel of improved quality. In the range of stresses $2500 < \sigma < 5000$ kg/cm² the author rejects the dependence on analysis and makes use of approximations "by eye."

The article was first published in 1934.

Ya. G. Panovko
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Experimental Stress Analysis

(See also Revs. 4195, 4210, 4211, 4212, 4213, 4214, 4215, 4216, 4233)

3932. Palmer, P. J., The bending stresses in cantilever plates by Moiré fringes, *Aircr. Engng.* **29,** 346, 377-380, Dec. 1957.

The bending stresses in plate models can be determined by means of the experimentally produced Moiré fringes, which give directly the gradients at all points of the surface of the model. It is shown that this technique can be used for cantilever plates with either uniform or nonuniform thickness provided that, in the latter case, the thickness is not large. The experimental technique is simple and yields stresses to an accuracy of about 10% and deflections to an accuracy of about 5%. Care must be exercised, however, at the edges of the model. The technique and apparatus are described; details of the experimental technique are given and discussed; and some resultant experimental fringe patterns are shown and analyzed. T. A. Hewson, USA

3933. Acloque, P., Method and apparatus for the instant determination of principal stress in two-dimensional photoelasticity (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 415-420.

3934. Betser, A. A., Flynn, P. D., and Frocht, M. M., On the stress-optic law under impact loading (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles 1957; **8,** 367-377.

Experimental studies of two one-dimensional cases: (1) A rectangular bar under longitudinal impact, and (2) a beam under central transverse impact, have indicated that the resulting birefrigence in the Castolite specimens tested is a linear function of the stress and the thickness and is independent (over the experimental range) of the velocity of impact used to produce the stress.

Electric resistance strain gages (SR 4-type C7) were found to have no effect on birefringence, and dynamic strains from these recorded from an oscilloscope were correlated with the corresponding photoelastic fringe patterns. The latter were obtained from a drum-type streak camera with slits parallel and transverse to the direction of wave propagation. Studies of case (1) yielded fringe patterns identical with those expected from the approximate Boussinesq solution.

A dynamic fringe value of 154 psi resulted from the dynamic modulus and strain gage studies; the compression bar gave 161 psi; and the static fringe value was found to be 163 psi. Authors conclude that dynamic and static fringe values are equal within experimental error. The dynamic fringe value based on the Boussinesq stresses shows a surprising 35% increase above the static value; this result is to be investigated further.

The brief paper carries excellent photographs of fringe patterns and C.R. tube traces for each of the cases studied. The report describes the progress made in the study (under the senior author's direction no doubt) of the dynamic stress-optic law.

R. Culver, Australia

3935. Niwa, Y., and Mori, C., Three-dimensional photoelastic stress analysis of a gravity dam, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 121-124.

3936. Kawata, K., Yokota, K., Tuzi, Z., and Kameshita, M., On the cementing method in making three-dimensional photoelastic models and the application to the photoelastic analysis of welded constructions, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 117–120.

3937. Goucharov, S. P., Kitsenko, V. V., and Margulis, A. I., Measurement of stresses and forces (a manual) (in Russian), Mashgiz, 1955, 68 pp. + illus., 2r. 40k; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1404.

The manual gives a brief exposition of the basic information on the experimental methods for investigating deformation and stresses in machine components. The following methods were examined: the strain-gage method, the optical polarization method, the method of brittle coverings. Considerable attention is given to the electric strain gage, based on the application of wire transmitters. Schematic arrangements and parameters are put forward of: an electronic apparatus applicable in static and dynamic investigations of stresses and deformation in machine components; in particular, details are given of the strain-gage appliance for measuring static deformation at a hundred points with automatic recording of the readings; of the five-channel strain-gage apparatus for the measurement of static and dynamic deformations with a frequency of from 0 to 1500 cps; of the multichannel apparatus (up to 10 channels) for studying dynamic deformation with frequencies of 20 to 5000 cps; with self-recording on a mirror or a cathode oscillograph; of the strain-gage appliance with an automatic cathode oscillograph for following processes with frequencies of 20 to 80,000 cps. Schematic plans and details of a considerable number of other types of strain-gages are given, and also of a series of appliances for the measurement of forces, pressures, velocities, accelerations, and so forth. Besides the description of apparatus the manual contains instructions on the methods of measuring deformation and the determination by these measurements of the parameters of the stressed condition, internal forces and moments acting in the machine components. In the chapters devoted to the method of brittle coverings and the optical polarization method, the essential nature of the methods is described, and information is given on carrying out experiments by the methods and on the treatment of the data obtained.

S. B. Boyarshinov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3938. Kolev, K. S., Measurement of deformations when determining residual stresses (in Russian), *Zavod. Lab.* **21,** 6, 750, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2497.

A method is described for the measurement of prismatic test samples, 140 × 15 × 7 mm, subjected along one side to the investigated mechanical treatment. The sample, with all the other sides protected, is placed on two supports in a special apparatus, where, by means of electro-etching, a progressive removal of the metal is accomplished from the cold-hardened surface. The author finds the value of the residual stresses in each etched layer by means of the measurements obtained of the deflections taken at equal intervals of time with the aid of an optimeter; the whole thickness of the etched surface was determined (corresponding to the complete removal of stresses); it was assumed that the etching proceeded evenly. The author's findings were based on previously developed methods.

E. M. Shevandin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3939. Takase, K., On the precise determination of general elongation, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 91–94.

3940. Taub, A., New reagent for microscopic stain analysis in steel, *Bull. Res. Counc. Israel* **6C,** 1, 29–32, Nov. 1957.

A newly discovered gold reagent permits quantitative microscopic strain analysis of steel specimens.

From author's summary

3941. Meyer, M. L., Measurement of local stress concentrations (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 469–479.

3942. Rebuffet, P., Some strain gage balances used in French wind tunnels, *AGARD Rep.* 6-T, 64 pp., Feb. 1956.

3943. Drew, D. A., Developments in methods of measuring stresses in compressor and turbine blades on test bed and in flight, Instn. Mech. Engrs. Prepr., 21 pp.

3944. Green, R. E., Two improved methods for determining Young's modulus, *Amer. J. Phys.* **26,** 4, 258–259, Apr. 1958.

Two methods are described for determining Young's modulus. The apparatus used in both cases utilizes a compensating device which eliminates the error caused by slippage or movement of the anchored end of the wire. The simplicity of the design of the apparatus described is such that it may be constructed in any school shop at a fraction of the cost of commercially available apparatus.

From author's summary

3945. MacKenzie, D. K., and Newcomb, T. P., The measurement of Meyer hardness and Young's modulus on the Rockwell test machine, *Brit. J. appl. Phys.* **8,** 10, 398–399, Oct. 1957.

A method is described in which the Rockwell hardness machine is used to determine the Meyer hardness and Young's modulus of a material. Meyer hardness values so derived for a number of materials are compared with those obtained from hardness measurements made on a Vickers hardness machine, and values of Young's modulus are compared with figures quoted in standard tables.

From authors' summary

Rods, Beams, Cables, Machine Elements

(See also Revs. 3901, 3911, 4001, 4010, 4016)

3946. Vainberg, D. V., Popkov, V. G., and Umanskii, E. S., Calculation of forces and deformation in the system of toothed wheels with spokes (in Russian), *Sb. tr. in-ta stroit. mekh. Akad. Nauk USSR* no. 20, 5–38, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1230.

A determination is submitted for the stressed condition of the system of a toothed wheel with spokes. The wheel is viewed as a multiple frame possessing cyclic symmetry. The following assumptions are made: (1) The rim of the wheel has a constant section and is investigated as a girder of small curvature. (2) The axis of the rim, the axes of all the spokes, and the external loads all lie in the same plane. (3) All the spokes are identical and rigidly fastened to the rim and the absolutely rigid hub. A numerical example is given for the calculation of the system of a toothed wheel in the reducing gear of a mine shaft hoist, and a summary of the formulas used in the calculations is included.

Yu. P. Grigor'ev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3947. Holdaway, A. E., A precise method of moment distribution, *Concr. constr. Engng.* **53,** 2, 73–78, Feb. 1958.

Author presents a method of moment distribution for solving continuous beams. The conventional moment-distribution method is a relaxation procedure, whereby the moment-distribution factors and carry-over factors are defined by clamping the two ends of a two-bay span. In the present method these factors are defined by

considering the actual supports of the beam and must be determined by taking the entire beam into consideration. By using these factors, however, the bending moments caused by any loading may be obtained in a single cycle. Author shows that the required moment distributions and carry-over factors can be expressed in terms of the conventional distribution and carry-over factors. T. H. H. Pian, USA

3948. Mellor, P. B., and Johnson, W., Approximate deflections in cantilevers curved in plan, *J. roy. aero. Soc.* **62,** 565, 64-66 (Technical notes), Jan. 1958.

Neglecting certain terms of the energy expression, authors derive approximate formulas for deflections and rotations at end of plane curved cantilevers of solid or annular circular cross section loaded arbitrarily. They also give a similar formula for deflection at intermediate points in special case. According to authors error is always less than 12%.

F. J. Plantema, Holland

3949. Antonevich, P. B., Problem on the calculation of the upper surface construction of a railway track (in Russian) *Trudi Leningr. politekhn. in-ta* no. 178, 253-259, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1244.

A method is submitted for calculations for the surface construction of a railroad, when considering the subsidence of each sleeper, not only owing to the forces directly applied to it, but also due to the pressures coming in from the neighboring sleeper. As an elastic foundation the simplified scheme of models proposed by M. M. Filonenko-Borodich [*Uch. zap. MGU, mekhanika,* 1940, no. 46] is adopted; this allows the consideration of not only the local but also the general deformation of the foundation. The problem resolves itself into the integration of the differential equation

$$\frac{\partial^4 w}{\partial y^4} - \beta \frac{\partial^2 w}{\partial x^2} + \gamma w = \frac{q(x, y)}{E_s I_s}$$

where w is the bending of the foundation, β and γ are constants linked with the basic parameters of the foundation, $E_s I_s$ is the rigidity of the sleeper when under deflection, while $q(x, y)$ is the intensity of the load. Fourier's integrals are applied for the solution. Expressions for the bending, angle of deflection, deflection moment, and the transverse forces in an arbitrary section of the rail are brought in in their integral form.

P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3950. Salion, V. E., Analysis of the stressed condition in the body of a disk wheel of the rotor shaft of a mine-shaft ventilator (in Russian), *Sb. tr. in-ta stroit. mekh. Akad. Nauk USSR* no. 20, 96-112, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1232.

The wheel of the rotor shaft of the ventilator is viewed as a multiple framework. The concentrated forces of inertia of the blades and the distributed forces of inertia of the spokes and rim of the wheel serve as a load. The cyclic symmetry of the system and the symmetry of the load set a problem of twice the statically indeterminable independent of the number of spokes. The remaining unknowns are determined by the method of forces on the assumption of the constancy of the rigidity of the rim. The calculation of the changing rigidity of the rim (an increase at the points of insertion of the spokes and a decrease at the points of fastening of the blades) leads to a reduction of the stresses calculated by 15% in comparison with the basic variable. A comparative analysis was carried out of the calculations for a cast metal wheel of the rotor of shaft-type mine-shaft ventilator, using different variables. The influence of the number of spokes on the stresses in the wheel of the rotor was investigated. The reduction of the number of spokes by half caused an increase in the maximum stress of 82%. Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3951. Segal', A. I., Calculations for guy rope systems (in Russian), *Trudi Mosk. tekhn. in-ta ryb. prom.-sti i Kb-va.* no. 5, 103-117, 1953; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1151.

The problem of the stiff mast guyed with a large number of ropes is solved by the method of deformations, while taking into account the chain stresses due to the gravity pull of the ropes, which leads to the nonlinear relation of the tension of the ropes to the change of position. The transcendental equations obtained are solved by the approximation method; first, on the assumption that the rope is inextensible, and then when considering its elastic deformations. Two numerical examples are given.

Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plates, Disks, Shells, Membranes

(See also Revs. 3903, 3910, 3932, 3968, 3969, 3970, 3971, 3972, 3973, 3975, 4003, 4295)

3952. Kacner, A., A closed solution in the case of a semi-infinite plate with discontinuous boundary conditions (in English), *Arch. Mech. stos.* **9,** 4, 371-380, 1957.

A uniformly loaded isotropic semi-infinite plate simply supported on both infinite (longitudinal) edges is considered. On the finite (transverse) edge, discontinuous boundary conditions of a special character are imposed, part of this edge being free, and the displacement of the remaining part, perpendicular to the plate, being directly proportional to the moments distributed along that part of the edge.

The kernel of Fredholm's integral equation of the second kind has in this case a very simple form. It enables us to reduce the integral equation by double differentiation to a differential equation. Its integral is expressed by elementary functions and satisfies the integral equation.

The case where the factor of proportionality between the deflection and the moment ω tends to zero is investigated. It is concluded that, in the extreme case, the function of moment in the open range does not depend upon its length, but it attains an infinite value at the boundary of the range.

In the summary, the author states that for $\omega = 0$ the solution loses its meaning. This is not exact, since it can easily be seen that for $\omega = 0$ a concentrated moment appears at the point of discontinuity, the value of which can easily be found.

Z. Kaczkowski, Poland

3953. Pinskii, M. G., A case of deflection of thin plates (in Russian), *Izv. Tomskogo politekhn. in-ta* **75,** 210-219, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2206.

The deflection is examined of a thin elastic plate fastened along its outer contour, when subjected to a moment applied to the rigid central round collar. The problem is solved in two ways. In the first, the solution is sought in the form $W(r, \theta) = (C_1 r + C_2 r^3 + C_3 r \ln r + C_4 r^{-1}) \cos \theta$, where r, θ are polar coordinates, $C_1, \ldots, C_4$ are constants; in the second, by means of functions of a complex variable for a plate of unbounded outer radius. The results for both the calculations for the boundary case agree. Expressions are given for the deflection, moments and transverse force in the plate. It was pointed out that in F. M. Dimentberg's solu-

tion of the analogous problem an error was tolerated [*Vestn. inzh. i. tekhnikov* no. 7, 415–418, 1938].

I. N. Vasitsina
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3954. Nariboli, N. A., Mixed boundary-value problems for rectilinear plates (in English), *Arch. Mech. stos.* **9**, 5, 507–524, 1957.

Consider an isotropic triangular plate clamped along part of one of its edges and simply supported on the remaining part of the periphery. The deflection surface of such a plate is found using the principle of superposition, the component deflections being the deflection of a simply supported plate due to the external load and the deflection due to the clamping moments acting along part of one edge. The unknown clamping moments are determined from a Fredholm integral equation of the first kind.

In the particular case where the whole of one edge is clamped the clamping moment is found by means of the Fourier transformation. Two cases are considered in more detail: (1) a plate in the form of a rectangular isoceles triangle clamped along one of the edges adjacent to the right angle; (2) a plate in the form of a rectangular triangle containing the angle of 30° clamped along the longer of the edges adjacent to the right angle. Uniform load is assumed in both cases.

Z. Kaczkowski, Poland

3955. Mushtari, Kh. M., An approximate determination of the reduction coefficient of the facing of a reinforced plane and cylindrical plate under axial compression (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i tekhn. Nauk* no. 7, 23–35, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 865.

An investigation is made of the transcritical deformation of a plate, reinforced by an orthogonal network of ribs, rigid and compressed in one direction. With the aid of the energy method an approximate determination is made of the stress in the median surface at different gradations of loading of the plate, and the reduction coefficients are computed. One of the variants of the solution concerns the case when points on the panel edge are not displaced in relation to corresponding points belonging to the ribs; in the second variant, the border points of the panel are assumed to be able to slide freely along the ribs. The reduction coefficients found for both the variants agreed closely with each other. Then there follows an examination of the large deflections of a round cylindrical panel, experiencing compression along the generatrix, after loss of stability. Values are established for the lower critical stress for panels having different initial curvature. The theoretical and experimental data concerning the reduction coefficients are compared.

A. S. Vol'mir
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3956. Kochanski, S. L., and Argyris, J. H., Some effects of kinetic heating on the stiffness of thin wings, Part 2, *Aircr. Engng.* **30**, 348, 32–40, Feb. 1958.

In part I of the paper [AMR 11 (1958), Rev. 2525] the authors investigated the effects of thermal stresses on the torsional and flexural stiffness of thin solid wings in the presence of small *deformations*. The present paper (part II) continues the analysis of part I and investigates the effects of large spanwise curvature and rate of twist on the distortion of the cross section when thermal stresses are present. The distortion of the cross section, that is, the bending of chordwise elements, is still regarded as small. The differential equation is derived for the distortion of the cross section (sufficiently removed from end effects) due to large spanwise curvature and rate of twist in the presence of membrane stresses arising both from temperature gradients and large bending and torsional deformations. Solutions are obtained for the moment-curvature and the torque-rate of twist nonlinear relations. The large deformations are shown to produce appreciable coupling between twisting and bending. Two cross sections are considered. For the flat plate, an exact solution of the differential equation for the cross section distortion is given. For the double wedge, an approximate solution is presented which is claimed to be sufficiently accurate for engineering purposes. The principal results are illustrated by several graphs.

R. L. Bisplinghoff, USA

3957. Hicks, R., Stresses in a cylindrical pressure vessel on a cylindrical support, *Engineer, Lond.* **205**, 5326, 274–277, Feb. 1958.

Superposing in the usual way the results from thin-shell theory, expressions are obtained for discontinuity stresses in pressure vessels on cylindrical supports (skirts) at the junction of cylinder, head, and skirt. Axial temperature gradient is taken into account.

H. Parkus, Austria

3958. Taylor, C. E., Elastic stability of conical shells loaded by uniform external pressure, Proc. Third Midwestern Conf. on Solid Mech., Univ. of Mich., Apr. 1957, 86–99.

Trefftz's theory of elastic stability is applied to thin conical shells loaded by external hydrostatic pressure. By differential geometry, a strain-energy expression is obtained based upon the assumptions that: (1) normals to the undeformed middle surface remain straight and normal to the deformed middle surface, (2) changes in the shell thickness have negligible effects on the strains in surfaces parallel to the middle surface, and (3) stresses perpendicular to the middle surfaces are negligible compared to the other stresses.

The divergence theorem is used to express the volume enclosed by the deformed middle surface in terms of a surface integral. The change in volume during buckling multiplied by the hydrostatic pressure is set equal to the potential energy of the external forces.

An approximate solution for the buckling pressure for complete conical shells is obtained by the Rayleigh-Ritz method. The inclusion of the additional quadratic terms in the energy expressions does not greatly affect the buckling pressures as obtained by the infinitesimal theory. However, the accurate strain-energy expressions will be necessary if large deflection theory is to be applied to conical shells.

From author's summary by F. Correia de Araujo, Portugal

3959. Shmurnov, K. V., Calculations for axially symmetrical parabolic shells (in Russian), *Sb. tr. Mosk. inzh.-stroit. in-ta* no. 8, 66–79, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2179.

Linear differential equations are deduced for the symmetrical deformation of shells of variable thickness, defined by the surfaces of the second order. Individual cases of these equations are referred to: equations for the deflection of cylindrical, conical and spherical shells. The principles are established for a change in the thickness of the shell, in consequence of which the solution of the problem becomes simple. It is shown, for instance, that the calculation for a conical shell of circular section with a thickness varying linearly, altering to zero at the vertex, converges with the calculation for a cylindrical envelope of constant thickness. The deflection of a parabolic envelope of constant thickness is looked into in detail. The problem is merged with the solution of Bessel's equation. It is demonstrated that in the zone sufficiently distant from the pole, and with an accuracy not exceeding the accuracy obtained with the theory of thin envelopes, it is possible to utilize the asymptotic separations of functions.

A. V. Sachenkov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3960. Kornetskii, A. L., Anchor ring-fashioned (toroid) shell with induced loading (in Russian), Calculation on the stability of the components of machine construction, Moscow, 1955, 35–45; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2180.

A method is proposed for calculating wind stresses on anchor ring-shaped shells $q_1 = q_2 = 0$, $q_n = q \sin\theta \cos\varphi$. With the aid of

a simple substitution the basic equation [see V. V. Novozhilov, "Theory of thin shells," Sudpromgiz, 1951] leads to a form having no properties in points of the meridian $\theta = 0$, $\theta = \pi$. At the same time, the homogeneous equation coincides with the analogous equation of symmetrical deformation, which opens up the possibility of using in the calculations the nomograms compiled by V. K. Naumov [*Tr. Leningr. Korablestroit. in-ta* no. 14, 200–214, 1954]. The particular solution is sought by means of the separation of the older derivative in the trigonometrical series. The accepted simplified expression for the angle of rotation ϑ (formula (46) page 43) in the article is not substantiated. K. F. Chernykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3961. Olesiak, Z., Discontinuous boundary conditions and linear supports in statical problems of cylindrical shells (in English), *Arch. Mech. stos.* **9**, 5, 550–563, 1957.

Vlasov's equations for a cylindrical shell with discontinuous boundary conditions on the rectangular contour are reduced to a system of Fredholm's integral equations of the second kind. They have the character of a condition of geometrical compatibility at the edges supported in a discontinuous manner, their kernels constituting the Green's functions for the shell equation. This method can easily be generalized to the case of shells with linear supports inside the rectangular region. Representing the kernels of the integral equations in the form of double trigonometric series and replacing the integrals with approximating sums author obtains the possibility of practical calculations.

M. Sokolowski, Poland

3962. Mickeladze, M. Sh., Rigid-plastic analysis of anisotropic plates and shells (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8**, 140–144.

Author first considers a sandwich-type shell having a core which resists only shear and faces thin enough that the stress may be assumed uniform across their thicknesses. A yield condition is assumed for the faces which reduces to the octahedral shear theory for isotropic material when, but only when, X_x and Y_y are principal stresses (a factor of 3 is omitted from the shear term). General equations are then written. Theory is said to be applicable with satisfactory accuracy to single-layer shells under some conditions.

Rigid-plastic bending of circular nonsymmetrical disks is also discussed. The yield condition is modified for this study. More details of author's approach to both problems are to be published in a Russian journal. A. D. Topping, USA

3963. Rassudov, V. M., Stressed and deformed state of a sloping orthotropic envelope, reinforced with rigid ribs (in Russian), Nauch. ezhegodnik za 1954g. Saratovsk. un-ta, Saratov, 1955, 688–689; *Ref. Zh. Mekh.* no. 1, 1957, Rev.

The deflection is examined of a thin slanting orthotropic envelope, rectangular in plane, with rigid ribs. The envelope bends with normal pressure, distributed over the envelope's surface. Differential equations are put forward for the deflection of the envelope and stress function, and also the boundary conditions in which integration of these equations follows.

E. F. Burmistrov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3964. Markov, A. N., Theory of orthotropic, very sloping envelopes (in Russian), Uch. Zap. Gor'skovsk. un-ta no. 28, 102–110, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 868.

An examination is made of the solution of the following problems dealing with an orthotropic sloping envelope, rectangular in plane: deflection of the envelope by a concentrated force, stability of the envelope, transverse oscillation and dynamic stability of the envelope. Several references to the literature are not forthcoming in the study. Some equations given in the article have already been published by Amburtsumyan [*Izv. Akad. Nauk ArmSSR* no. 9, 1947].

E. F. Burmistrov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Buckling Problems

(See also Rev. 3958)

3965. Zyczkowski, M., The influence of a decrease of eccentricity on the deflection of a bar subjected to eccentric compression (in Polish), *Rozprawy Inz.* **5**, 3, 399–419, 1957.

In addition to the constant eccentricity the author considers an eccentricity normal to the tangent to the axis of the bar and compares the absolute and relative deflections in both cases. The extremal case is that of elastic deflection when the eccentricity approaches zero. The results are gathered in two tables. Diagrams of deflections in the coordinates *initial eccentricity-force* are presented in both cases of eccentricity for absolute and relative differences of deflection. The paper enables the calculation of the elastic deflection with an accuracy sufficient for engineering purposes and the appraisal of the difference of deflection between the two schemes. Z. Olesiak, Poland

3966. Rabotnov, G. N., and Shesterikov, S. A., Creep stability of columns and plates, *J. Mech. Phys. Solids* **6**, 1, 27–34, 1957.

Contrary to N. J. Hoff and others [AMR **8** (1955), Rev. 2444; **9** (1956), Rev. 2915], author treats creep buckling problems as stability problems for originally straight columns instead of creep deformation problems for originally curved columns. Theory is a "strain-hardening theory" based upon an arbitrary "equation of state" connecting stress, plastic strain and plastic strain rate. Thus primary creep is taken account of in a phenomenological sense, but the characteristic asymmetry of creep buckling, considered by reviewer [AMR **8** (1955), Rev. 1002] and J. Hult [AMR **9** (1956), Rev. 740], gets lost. Considering small increments in stress and strain, author derives a corresponding linear partial differential equation for column deflection y, the coefficients of which depend on time t. Assuming y of form $y = r(t) \sin \pi x/a$, where a is length of column, boundary conditions for hinged column are satisfied and a third-order ordinary differential equation for $r(t)$ is obtained. Conditions for coefficients of this equation securing monotonous increase or decrease of $r(t)$ form buckling criterion.

Simplified criterion for time-independent solution is studied separately, assuming equation of state in well-known form, e.g., that of A. Nadai and coworkers. Theory is generalized to plates. Assuming incompressibility, author puts strain-rate tensor proportional to stress-deviation tensor. Factor of proportionality is taken as function of second-order stress deviation invariant and a strain invariant depending on strain history. As an alternative to such "flow" theory, a "finite" theory is also given. Partial differential equations for plate deflection are deduced. Special problem of uniformly compressed plates is studied more in detail.

F. K. G. Odqvist, Sweden

3967. Weingarten, V. I., Buckling of a simply supported rectangular plate under compression reacted by shear, *J. aero. Sci.* **25**, 3, 207–208 (Readers' Forum), Mar. 1958.

The energy method was used to find the critical buckling load of a simply supported rectangular plate under compression reacted by shear. The plate here considered is assumed to follow the classical small-deflection theory. One point was checked by the method of finite differences. Results are presented graphically.

From the author's summary by A. R. Mitchell, Scotland

3968. Klosner, J. M., and Forray, M. J., Buckling of simply supported plates under arbitrary symmetrical temperature distributions, *J. aero. Sci.* **25,** 3, 181–184, Mar. 1958.

The plane stress problem is solved for rectangular plates having temperature distributions symmetrical about their centerlines and edges stiffened by supports which can stretch but not bend. The deflection function for the buckled plate is then approximated by the first four terms of a double infinite harmonic series, and the Rayleigh-Ritz procedure is used to determine approximately when initial buckling occurs.

From authors' summary by L. Maunder, Scotland

3969. Cutcliffe, J. L., and Heaps, H. S., Symmetrical buckling of a series of uniformly loaded parallel struts supported by spot connections to a long thin plate, *J. appl. Mech.* **24,** 4, 531–536, Dec. 1957.

A long panel consisting of a range of equal parallel stiffeners across a rectangular plate is considered under the condition that equal buckling loads are applied to the ends of each stiffener. For each stiffener, the second-order condition is used (equilibrium after deformation). But for the plate the author uses only the first-order condition (equilibrium before deformation), with boundary forces coming from the second-order equilibrium of the stiffeners. Reviewer believes that at certain practical values of the dimensions this procedure may give nearly the same values for the critical load as an exact solution of the complete second-order problem.

H. Neuber, Germany

3970. Shuleshko, P., Buckling of rectangular plates with two unsupported edges, *J. appl. Mech.* **24,** 4, 537–540, Dec. 1957.

Using the general solution of the differential equation for the second-order equilibrium (after deformation) of a rectangular plate under uniformly distributed compressive forces in two perpendicular directions, author verifies the conditions that two opposite edges are simply supported while the two other edges are free. The parameter of the critical load is calculated numerically.

H. Neuber, Germany

3971. Maksimadzhi, A. I., Stability of plates compressed in two directions and their behavior after loss of stability (in Russian), *Trudi Tsentr. n.-i. in-ta mor. flota* **1,** 1, 74–98, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2192.

A detailed study is made of I. G. Bubnov's solution ["Treatise on the theory of plates," Moscow, 1953] of the stability of a freely supported rectangular plate compressed in two directions, and convenient curves are presented for its computation. The main contents of the article concern the investigation of the same plate after loss of stability. The problem is solved by applying P. A. Sokolov's boundary conditions ["On the stresses in compressed plates after loss of stability," Moscow–Leningrad, 1932] i.e., when tangential stresses are absent on the contour and when the rectilinear state of the edges is preserved after the loss of stability. Depending on the ratio of the sides of the plate, the expressions for the line of the plate's deflection are presented in the form of one or two terms of a trigonometrical series in Karman's system of differential equations and are integrated by Bubnov's method. Curves are given for the reducing coefficients, when there is compression from two directions, for various values of the sides ratio and the ratio of the compression stresses in rigid bonding.

A. A. Kurdyumov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3972. Sachenkov, A. V., Approximate determination of the lower limit of critical loading when a thin conical envelope is subject to longitudinal compression (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz. matem. i tekhn. nauk* no. 7, 16–22, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 861.

Differential equations are formulated describing large deflections of circular conical envelopes; use is made of expressions for the deformation in the median surface of the envelope, devised by Kh. M. Mushtari [*Prikl. Mat. Mekh.* **2,** no. 4, 1939], with the squares of transfers and their derivatives taken into account. The author shows that when deformation is typified by local loss of stability these equations merge into the system relating to sloping envelopes [V. Z. Vlasov, "General theory of envelopes," 1949] and appraises the order of the terms thrown off in the process. A simplified system of equations is applied to study the hypercritical deformation of the truncated round conical envelope exposed to the action of axial compression. Expanding, to meet a given case, the computations of Micheilsen, carried out by him for a cylindrical sheath [*J. aero. Sci.* **15,** no. 12, 1948], the author arrives at the following approximate formula for the lower critical value of the axial stress:

$$P_n = 0.195\pi.\ 8\ Eh^2\cos^2\gamma$$

(where $2h$ is the thickness of the envelope, 2γ is the angle of opening of the cone). Analogous approximate formulas are put forward to meet the cases of envelopes, with curvature of Gauss = 0, of some other outline.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3973. Surkin, R. G., On the theory of the stability of an elongated ellipsoidal shell of rotation when subject to external evenly applied pressure (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i. tekhn. nauk* no. 7, 3–15, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 860.

A study is made of the influence of the local loss of stability "in the large" of a thin closed shell, having the shape of an ellipsoid of rotation and finding itself under the influence of an evenly distributed external pressure. Transposition of points u, v, w of the median surface is carried out with the help of expressions containing hyperbolic functions; in so doing the transpositions, as also the forces, die out on the boundary of the region of the ellipsoid. The principal radii of the curve of the median surface situated in the limits of this region, having the shape of an ellipse, are taken to be constants. The total energy of the system is calculated. Further, determinations are made of: (1) pressure p_M at which the levels of energy of the original and bent conditions of the shell are equal to each other; (2) lower critical pressure p_K, which on the graph "energy—deflection" is represented by a parabolic point. These values are compared with the upper critical pressure determined by means of the linear theory.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3974. Spitsyn, A. D., Investigation on the longitudinal stability of a mining "tub" (in Russian), *Sb. nauch. tr. kazakh. gorno-metallurgich. in-ta* no. 9, 320–326, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 84.

The problem is studied of the static longitudinal stability of a two-axled mining tub on a horizontal track when loaded unevenly (one-sided) with heaped material. Recommendations are made for optimum correlation linked with the linear dimensions of the tub.

L. A. Rozenberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3975. Sundstrom, E., Creep buckling of cylindrical shells, *Acta Polyt.* no. 230, 31 pp. + 7 tables, 1957.

Elastic-viscous instability of cylindrical shells is studied in order to find their critical buckling time when submitted to ex-

ternal pressure. Primary and secondary creep are supposed to follow nonlinear power laws. Formulas, diagrams, and tables are given for computing stresses and lifetime of tubes and curved panels. A double-membrane analogy is used. Conclusions are valid for long tubes and panels with axial stresses lower than circumferential ones. H. Fernandez Long, Argentina

3976. Szmodits, K., Examination of the stability of frames of varying cross section (in Hungarian), *Magyar Tud. Akad. Oszt. Közl.* **19,** 1/3, 201–210, 1956.

The least value of the factor will be determined by which the load has to be multiplied to obtain a multivalued equilibrium state. It is supposed that the frame behaves elastically. The kinematical method of stress analysis is used for solving the problem. The exact result will be approached by assuming the multiplying factor at random. J. Barta, Hungary

Joints and Joining Methods

(See also Revs. 3993, 4015, 4323)

3977. Perkins, R. H., and Suddarth, S. K., Shear-pin joints with 2 × 4, 2 × 6, and 2 × 8 lumber for axial loading, Purdue Univ. Research Bull. no. 659, 18 pp., Feb. 1958.

Test data are presented for Douglas fir joints with (1) shear pins inserted for load transmission into holes predrilled undersize or exact-size, and (2) transverse bolts inserted into oversize predrilled holes to prevent separation of the members. The recommendation is made to use this type of joint only for lumber having a moisture content of less than 14%.

E. G. Stern, USA

3978. Lightfoot, E., Substitute frames in the analysis of rigid-jointed structures. Parts I, II, *Civ. Engng., Lond.* **52,** 618, 1381–1383, Dec. 1957; **52,** 619, 70–72, Jan. 1958.

In previous papers [AMR **10** (1957), Revs. 3267, 3268] author has presented a method by which multistory, multibay rectangular rigid frames are analyzed through application of a moment distribution process to a much simplified substitute frame. This consists of a single column with total stiffness in any story equal to the sum of the stiffnesses of the actual columns, combined with beams, extending to one side only, having their far ends pinned, at all stories. The substitute beams have stiffnesses that are 12 times the total of those of the actual beams in corresponding stories. Analysis of the substitute frame yield moments, etc., that are compatible with certain deformations and are in equilibrium with the external loads. Apportioning the moments of the substitute frames among the members of the actual frames yields a set of moments that are compatible with the distortions of the frame (same as those of the substitute) but are not generally in equilibrium. In the earlier papers (see ref.) the normal moment distribution-sidesway process was next used to find the equilibrium state. In the paper now under review the out-of-balance moments are adjusted by use of the same or another substitute frame. This is an interesting and ingenious approach which saves much time.

In part II, author illustrates the use of substitute frames described in part I of this paper. M. P. White, USA

3979. Noren, B., Yielding of a nailed joint under bending forces, *Sven. Traforsklnst. Medd.* 89 B, 7 pp., 1957.

In beams, rafters in roof structures and other elements of wood, joints can be designed to give full ultimate bending strength, i.e. to give the strength of the members on either side of the joint. Contrary to glued joints which are very stiff, joints with nails, screws and similar fasteners, though strong enough, yield to an extent which in most cases should be considered. This paper deals with a nailed double lap joint which has been tested in bending in order to determine a certain yielding factor g, for use when calculating deformation. The main part of this factor is due to the slip in the joint (δ in Fig. 2) and a minor part is dependent on the stiffness of the side members. The deflection of beams in one piece and beams with a nailed joint in the middle of the span is reproduced (Fig. 3). From the deflection curves the yielding factor of the joint was calculated and plotted against the bending moment (Fig. 4). The result is compared with the fundamental elasticity coefficient of wood under a nail (K). Finally, the result is applid to two problems (Table 3 and Fig. 5) in which the practical significance of the yielding of joints is exemplified.

From author's summary

3980. Bohn, G. H., Selection of welding-rod chemical composition through mathematics, *Welding J.* **36,** 12, 541s–549s, Dec. 1957.

Paper presents the procedure that was used for determining the most satisfactory chemical composition for the copper-silicon-manganese-iron alloy welding rod. A mathematical formula was developed to determine the minimum resultant tensile strength of the weld as a function of the silicon, manganese and iron contents. The desired fluidity of the weld pool, to eliminate weld cracking, was obtained by maintaining the ratio of silicon to manganese to an experimentally determined minimum.

Finally, as a result of the data presented, it is suggested that certain slight revisions be made in the chemical composition in present specifications for the copper-silicon welding rod.

From author's summary

3981. Didov, V. B., The forces produced by a tire when it is shrunk on hot on the wheel center (in Russian), *Tr. Mosk. in-ta inzh.zh.-d. transp.* no. 82/83, 120–133, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1254.

An approximate calculation is set forth for the forces formed when a wheel tire is shrunk on with a tightening effect on the wheel center, consisting of the rim, spokes and hub. The union between the tire and the rim after the operation may be viewed as a system of springs, connecting their axes and directed along the normal to the rim; their reciprocal action is presented in the form of a normal reaction of an elastic base of the "Zimmerman-Winckler" type. The rim and the tire are examined as curvilinear bars of small curavture on an elastic base. A numerical example of the calculations is given. Some doubt is aroused in regard to the original assumption for the coefficient of rigidity k, the value of which is not shown to be justifiable.

D. B. Vainberg
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3982. Moiseev, I. A., Problem of raising the vibration endurance of lap joint welding (in Russian), *Trudi Vses. n.-i. in-ta zh.-d. str-va i procktirovaniya* no. 10, 91–109, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1258.

Results are furnished of the investigation on the vibration endurance of welded lap joint connections in a pulsator when variable tension stresses are operating. The author concludes that the rules used in practical conditions for the calculation of welded joints of the lap-joint type, with angular seams in cases of variable and slightly variable stresses, require re-investigation. Lap-joint bonding, carried out by means of single side seams, is somewhat inferior to the combination bonding, consisting of two side and one facing seam. The greatest endurance is shown by the

combination of a lap-joint welding with the reheating of the welding metal along the whole length of the joint.

V. S. Ignat'eva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3983. Bakshi, O. A., Investigation of deformations when spot welding (in Russian), *Sb. statei Chelyabin. politekhn. in-ta* no. 7, 14–40, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2467.

A method is described for the approximate determination of the line of deflection in the components of a steel of low carbon content, spot welded, and the results are given of the experimental check of the proposed method. The basis of the theoretical determination of deformations is furnished by the author's previously solved problem on the intermittent and residual stresses and deformations when the steel sheet is axisymmetrically heated. According to this solution, in the diameter region $2b_{max}$, somewhat higher than the diameter of the molten nucleus of the welding spot, after cooling, tension in all directions takes place, equal to $2\sigma_s/\sqrt{3}$ (σ_s being the limit of flow of the material). The bending moment M_x is determined as the sum of the moments comprising the elementary radial forces, directed parallel to the axis of the strip. When determining the deflection, the curve M_x, appearing as a distributed fictitious load q_x^{Φ}, is replaced by the concentrated fictitious force P^{Φ}. According to the calculation made

$$P^{\Phi} = \frac{2\pi\sigma_s b^2_{max} b e_0}{\sqrt{3}(b - \sqrt{\pi} b_{max})}$$

where b is the width of the strip, and e_0 is the eccentricity. The deflection in an arbitrary section is determined as the ratio of the bending moment of the fictitious forces M_x^{Φ} to the rigidity of the strip in section, weakened by the opening $f_x = M_x^{\Phi}/El_1$. This method of determining the deflection is also applicable to cases of welding of the simplest beams. In the calculation the pressure of the electrodes and the irregular thermal spread of the elements being welded (the flow of one element on to the other in the process of welding) are disregarded. The experimental check disclosed that these factors have a secondary significance, and confirmed the possibility of application of the given method in a considerable wide range of welding processes (regimes). The method of carrying out the experiments is described and photographs are given of the experimental apparatus. Deflection was determined by measurements showing the difference in readings up to and after the welding. Curves are given showing the alterations of the line of deflection with time, and also curves showing the dependence of deflection on the amount of heat Q introduced into the components when making a single spot welding. Deformation increases with the increase of Q to Q-critical and then starts to decrease with the increase of Q.

V. S. Ignat'eva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3984. Partiarca, P., Slaughter, G. M., and Manly, W. D., Heat-exchanger fabrication, *Welding J.* **36,** 12, 1172–1178, Dec. 1957.

Welding and brazing procedures used in the fabrication of nickel-base alloy heat exchangers for elevated-temperature service are described.

From authors' summary

3985. Navrotsky, D. I., Saveliev, V. N., and Luchkin, P. N., An investigation of the stress distribution in a joint with a double-sided gusset plate (in Russian), Sovbshch. N.-i. in-ta mostov pri LIIZHT no. 16, 12 pp. 1954; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 7060.

The stress distribution in a joint with a double gusset plate is investigated. The tests were made on a horizontal tensile testing machine. The strains were measured by wire tensometers.

K. I. Kadariya

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3986. Bandaruk, W., Adhesives for high-temperature applications, *Prod. Engng.* (Design Digest Issue) **28,** 15, G25–G27, Oct. 1957.

3987. Dixon, R. R., Screw-holding power of polyester laminates, *Prod. Engng.* (Design Digest Issue) **28,** 15, G22–G24, Oct. 1957.

3988. Thermo-compression bonding, *Bell Lab. Record* **35,** 9, p. 336, Sept. 1957.

3989. Siekmann, H. J., Bonding ceramic tool tips to steel shanks, *Tool Engr.* **39,** 1, 101–104, July 1957.

Structures

(See also Revs. 3947, 3968, 3976, 3978, 3987, 4017, 4019, 4163, 4295, 4320)

Book—3990. Gaylord, E. H., Jr., and Gaylord, C. N., Design of steel structures, New York, McGraw-Hill Book Co., Inc., (Civil Engng. Series), 1957, xvi + 539 pp. $8.

The subject—design of structural members and their connections, with applications to bridges and building frames in steel, and also in aluminum—is presented as thorough textbook for better understanding of basic structural philosophy. Theory, tests, design specifications and illustrative examples will appeal to both the student and practicing engineer. Of special interest are discussions of design calculations for several structures that have actually been built. Chapters refer to all kinds of loading, specifications, design procedures, structural types, connections, tension and compression members, beams, combined stresses, plate girders, industrial buildings, bridges, multistory buildings, portal frames, plastic design. New treatment of bending about both principal axes and lateral buckling of beams is of interest for its simplicity and reliability. The book is another valuable volume of McGraw-Hill Civil Engineering Series.

J. J. Polivka, USA

3991. Lightfoot, E., Generalized slope-deflection and moment distribution methods for the analysis of viaducts and multi-bay, ridged portal frames, *Struct. Engr.* **36,** 1, 21–33, Jan. 1958.

Referring to some recent papers, investigation especially deals with linear structures, i.e. general frames with curved members but straight vertical columns. Basic relations describe moments and forces occurring by rotation and displacements of the one joint end of a member, the other being clamped or hinged. Together with the values due to the load (ends fixed or hinged), conditions of equilibrium in each point lead to a set of equations whose number is the same as the number of unknown (and possible) movements; in general case three at each joint, for linear structures only two. Finally, basic relations transfer characteristic displacements into moments and forces needed.

Analogically, stepwise fulfilling of balance conditions at each joint leads to a method of moment and thrust distribution balancing simultaneously either moments and forces in all directions. Therefore three or two tables are needed in general case and that of linear structures, respectively.

Minimizing the computational work is accomplished by using properties of symmetry. Author proposes preparation of tables for

stiffness and restraint factors and fixed end moments of often used member types. W. Mudrak, Austria

3992. Kornishin, M. S., and Mushtari, Kh. M., Stability of an infinitely long slanting cylindrical panel under the effect of a normal evenly applied pressure (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i tekhn. nauk* no. 7, 36–50, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 864.

The theory is set out for large deflections of a slanting infinitely long cylindrical panel of circular outline, when subjected to a uniformly applied normal pressure, seen from the buckling view-point. The edges of the panel are taken to be not subject to displacement; cases are examined of jointed support and fastened edges. Equations are given connecting the deflection axis of the panel and the forces in the median surface with the intensity of the stress, during which, within the limits of assumptions for the theory of slanting envelopes, these relations manifest themselves as accurate. A detailed analysis is carried out on the nature of the panel deformations of different curvature. The conditions for formation of a loop-shaped curve on the graph "deflection-loading" are found and the upper and lower values of the intensity of load are indicated. An estimate is made of the influence on the behaviour of the panel of the original irregularities in relation to the circular shape. It is shown that the assymmetrical original buckling failure can strongly influence both the upper and the lower critical loading. Some relations having a bearing on the accurate solution of the given problem were obtained earlier by I. G. Bubnov [*Trudi po teorii plastin*, 282–284, 1953]. A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3993. Mordvintseva, A. B., Deformation of welded structures with the passing of time (in Russian), *Sb. statei Mosk. vyssh. tekhn. uch-shcha* **37,** 47–59, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1260.

A study was made, using special ring test pieces and with the help of indicators, of the deformation, after welding and with the passage of time, of different grades of steel. Experiments showed that low-carbon and austenitic steel practically do not deform with the passage of time; all alloy steels for construction work of marks 23X2NVFA, 12X5MA, 2OXGSNA, 25XGS and EOXGS deformed during the whole period of the investigation, up to one year. During this time, in all cases, the deformation takes place with an increase of the volume of metal in the zone of the welded joint. It was established that the deformations proceed at first with great speed, then slow up and, later, gradually tend to die away. However, the observations showed that even after a lapse of two years deformations did not cease. The regularity of the processes obtained made it possible to assume that the cause of deformation of the welded samples is the disintegration of the residual austenite, which in any condition is accompanied by an increase in the volume of the metal.

The change in dimensions, due to the influence of the disintegration of the residual austenite, at room temperatures, was under observation on hardened rectilinear samples of steels 12X5MA and 23X2NVFA, fastened in a special device. The deformations were measured by means of a strain gage for measuring deformation of loaded mechanisms. These experiments showed that retarded cooling (in the air) assists the increase of deformation at room temperature. It was established that with the diminution of the linear energy of the welding the deformation decreases. The employment of even insignificant warming up when welding increases the subsequent deformation. If welding is carried out in the fastened condition of the test specimen the subsequent deformation decreases. The hammering of the seams after welding completely excludes a subsequent tendency to deformation, which is explained by the acceleration of the process of disintegration of the residual austenite under the influence of increase of plastic deformations. G. A. Nikolaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3994. Argyris, J. H., and Kelsey, S., The matrix force method of structural analysis and some new applications, *Aero. Res. Counc. Lond. Rep. Mem.* 3034, 33 pp. + 9 tables + 16 figs., 1957.

In this paper the basic principles of the matrix force method of structural analysis previously given by the author in *Aircraft Engng.* **26,** Oct., Nov. 1954; **27,** Feb., Mar., Apr., May, 1955, are concisely summarized. The great systematization of the computations by the use of matrix algebra is emphasized and it is shown that once the elements of the basic matrices involved in the analysis are determined, the subsequent labor consists of a few matrix operations that can be performed by a modern digital computing machine with facility. The analysis is developed in general terms and is applicable to any structure composed of an assemblage of arbitrary elastic elements. The general theory is illustrated by applying it to redundant aircraft wing structures.

An ingenious and efficient method for the determination of the stresses and displacements due to thermal or other initial strains is presented and a powerful technique for solving problems involving structural modifications such as cut-outs or changing the flexibility of certain component members is developed.

In the opinion of the reviewer, this paper is a notable contribution to the theory of structures and should be studied by engineers whose field of concentration is structural analysis and design.
L. A. Pipes, USA

3995. Kachurin, V. K., Some problems on calculations for skew bridges (in Russian), *Sb. Leningr. in-ta inzh. zh.-d. transp.* no. 146, 283–290, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1140.

This is an approximate calculation for narrow sandwich-beam skew bridges having two principal beams and supported at four points. Formulas are given for the determination of the values of the supplementary deflection and torsion moments, stipulated by the obliquity of the bridge, when the bridge is subjected to an evenly distributed load. The influence of the obliquity decreases in proportion to the diminution of the resistance to torsion of the rigidity of the bridge. The numerical calculation indicates that the application of the formulas for a straight bridge in the case of presence of skew leads to significant errors in regard to the stress values (up to 50% in the example investigated). A method is proposed for the approximate setting up of lines of influence for the case where there is displacement along the axis of the single load. Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3996. Umanskii, A. A., and Kutukov, B. N., Calculations for continuous pontoon bridges (in Russian), *Raschet prostranstvennykh Konstruktsii, Moscow, Gos. izd-vo lit po str-vu i arkhitekture* **3,** 1955, 85–135; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1144.

An examination is made for the calculation of a continuous floating bridge viewed as a beam, lying on elastic, yielding supports. To begin with, an investigation is made of the infinitely extended beam, and then, by introducing supplementary loads, the boundary conditions of a finite system are satisfied. Lines of influence are built up for the supporting and deflection moments in different sections. An examination is also made of the torsional bending of the pontoon bridge on the assumption that the crossbeams are absolutely rigid or elastic.

E. Kh. Arabadyan and S. N. Nikiforov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3997. Mitropol'skii, M. N., Regulation of stresses in unjointed arched ferro-concrete bridges when taking continuous processes into account (in Russian), *Trudi Mosk. in-ta inzh. zh. d. transp.* no. 85/6, 127–155, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1133.

An analysis is made of the influence of various factors on the creep of cement and on the lowering of artificially created stresses in unarticulated ferro-concrete arched bridges. On the basis of this analysis some practical recommendations are given in regard to the selection of the composition for the concrete, and also for the procedure to be followed in carrying out the regulation of stresses in the arches. Some tables, both new and useful, have been compiled for calculations, supplemented by a curve for one year's increase from the known nomogram of I. I. Ulitskii ["Calculation of concrete and ferro-concrete arched and combination structures, having regard to continuous processes," Gosteizdat Ukrainu, 1950], to determine the final extent of creep. Examples of the calculations are given. The known works of Dischinger on the same subject [F. Dischinger, *Bauingenieur* 1937: nos. 33/34, 35/36, 39/40; 1939: nos. 5/6, 21/22, 31/32, 47/48] should be referred to, though not cited by the author.

A. A. Pikovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3998. Luca, M., Installation and mechanical equipment for precasting large structural slabs (in Rumanian), *Indust. constr. Mater. constr.* **8**, 7, 384–387, July 1957.

Description of the prefabrication plant for slabs cast of concrete with vulcanic ash and ceramic aggregates, installed on the construction site of a huge student dormitory.

J. J. Polivka, USA

3999. Mihai, I. P., Prestressed insulated concrete roofs for heated industrial plants (in Rumanian), *Indust. constr. Mater. constr.* **8**, 7, 375–384, July 1957.

Study of special types of composite roof structures consisting of typical prestressed joists combined with insulating lightweight-slabs interconnected with stirrups. Design is thoroughly discussed and analyzed for standard top slabs 30 × 60 in. with 4 inside holes in distances 15 and 30 in., 30 in. being the spacing of the supporting joists. Nine different types are investigated for spans from 7 to 20 ft, with tabulated results, amply illustrated, with all characteristic properties, especially thermal insulation, bearing capacity and waterproofing. Very good results were obtained with slabs of cellular concrete cured under steam pressure. Various details of periphery joints and their grouting methods are described. Calculation method is demonstrated by examples.

J. J. Polivka, USA

4000. Forssell, C., The design of reinforced concrete, *Kungl. tekn. Hogskol. Handl.* no. 117, 25 pp., 1957.

Paper is primarily directed at modifying the formula for bending stresses in an "elastic" beam ($\sigma = Mc/I$) to apply to reinforced-concrete beams. An expression is developed from tests of rectangular reinforced-concrete beams which states the limiting concrete stress to be given by $c_0 \cdot 6M_u/bd^2$, where c_0 is a coefficient based on the tests, $6/bd^2$ is the "elastic" section modulus for a rectangular beam, and M_u is the ultimate moment.

C. P. Siess, USA

4001. Dolobko, T. M., Distribution of natural stresses in prestressed ferro-concrete beams with interlinking (in Russian), *Stroit. prom-st'.* no. 2, 33–36, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1177.

The distribution of prestressing forces was investigated, both along the length and up to the height of beams, reinforced but with no tie rods at the ends. The investigation was carried out by the optical method on models made of celluloid with copper wire reinforcement, and also on ferro-concrete beams with reinforcement of high tensile wire from wire hawsers. Natural stresses were measured by means of strain gages. Diagrams were obtained for the tangential stresses along the length of the beam and of the normal stresses along the height of the beam in different sections. The experimental values for the stresses agreed well with the theoretical. On the basis of the experiments a formula was evolved for the forces along the length of the beam. The slip of the reinforcement was not taken into account in the experiments.

N. D. Zhudin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4002. Krylov, V. Ya., Transverse stability of a triangular wing (in Russian), *Trudi Leningr. in-ta aviats. priborostroeniya* no. 4, 17–25, 1953; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1622.

A qualitative evaluation is given of the transverse stability of a triangular wing without reduction in area compared with a rectangular wing.

B. V. Raushenbakh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4003. Peterson, J. P., Weight-strength studies of structures representative of fuselage construction, *NACA TN* 4114, 47 pp., Oct. 1957.

This report compares strength-to-weight ratios of circular cylindrical beams designed to resist pure bending and bending and shear. The beams are of four basic types of construction: ring stiffened shell, longitudinally stiffened shell, sandwich shells with a waffle-type core, and sandwich shell with a honeycomb core. Data and procedures are taken from a number of references which deal with various phases of this problem. From these procedures (which often involve empirical factors not defined in the present report) curves of a weight parameter versus a loading parameter are plotted for the various types of construction with the cylinder radius to shell thickness as a parameter. The preliminary designer may use these charts to obtain quickly an approximation of the most efficient type of construction and material to transmit a given moment and shear load in a fuselage-type structure for a given temperature. The charts show that sandwich type of construction is considerably more efficient; however, weight of bonding materials is not included in the weight parameter for the sandwich construction.

D. W. Breuer, USA

4004. Miura, K., An approximate solution for stresses and deformations of swept wing, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 39–42.

An analysis of swept wings is presented much along the lines of earlier approximate box beam theories. Author assumes a complementary triangular section added to the triangular root section of the wing, thus extending the structure beyond its actual support and assumes it built in at the transverse bulkhead which has been added. The complementary section is given infinite structural rigidity. Merits of this procedure are not clear. Text and analysis are somewhat hard to follow—a minimum of illustrations accompany the definitions and nomenclature.

F. T. Geyling, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 3917, 3962, 3966, 3975, 4053, 4060, 4061)

Book—4005. Eirich, F. R., edited by, Rheology, Vol. II. Theory and applications, New York, Academic Press Inc., 1958, xiii + 591 pp. $18.

This second volume of a trilogy on rheology maintains the high standard set by the first one. It contains 13 articles, each one by

an outstanding expert in the field; some articles refer to fundamental aspects of theory and measurement technique, but on the whole emphasis has shifted to applications and treatment of flow behavior of special substances. In the following the contents are arranged under several headings which show the structure of the work. I. Viscoelastic theory and polymers in general are discussed in three articles: The phenomenology of linear viscoelastic theory is given by H. Leaderman in "Viscoelastic phenomena in amorphous high polymeric substances." The counterpart to the theory is found in "Experimental techniques for rheological measurements on viscoelastic systems" by J. D. Ferry, and "Stress relaxation studies of viscoelastic properties of polymers" by A. V. Tobolsky shows experimental results and their analysis within the framework of linear theory. II. The rate theory, which gives insight into the mechanism of flow properties of matter, is treated by T. Ree and H. Eyring in "The relaxation theory of transport phenomena." III. A series of articles treats the rheology of special substances, e.g. organic glasses (R. Buchdahl), Raw elastomers (M. Mooney), Cellulose derivatives (E. B. Atkinson), Fibers (R. Meredith), Gelatin (A. G. Ward and P. R. Saunders), and Asphalt (R. N. Saal and J. W. A. Labout). "Rheological problems of the earth's interior," by B. Gutenberg, gives a comprehensive survey of processes associated with the flow properties of the earth's core. IV. Finally, important experimental techniques of a specialized nature are discussed in "Fundamental techniques: fluids" by B. A. Toms, and "Goniometry of flow and rupture" by A. Jobling and J. E. Roberts.

The book contains a wealth of data and is strongly recommended to the research worker in the field and to the applied scientist who needs information on specialized theoretical or experimental techniques of particular substances. B. Gross, Brazil

4006. Rivlin, R. S., Some flow properties of viscoelastic fluids (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3**, 187–195.

In specifying possible properties of non-Newtonian fluids the author admits a wide range of functional relations between the kinematic quantities and the stress, restricting them by the postulate of isotropy and other plausible conditions. Equations of motion of non-Newtonian fluids are solved for three simple systems. Considering the flow of a cylindrical mass of fluid between parallel plates in relative rotation ("torsional" flow), the normal and tangential stresses acting on the free cylindrical surface are derived in general terms. The results are used for deriving the normal and tangential stresses in "helical" flow, meaning the flow of a liquid between concentric cylinders in relative rotation and under the effect of an axial pressure gradient. Calculations in greater detail are made for the flow through a tube of uniform cross section. Flow in axial streamlines is incompatible with the equations of motion unless the cross section is circular. Calculations are carried through for a tube of elliptical cross section, eccentricity being small. It is found that the fluid performs circulating movement in every quadrant.

In assessing the significance of the author's approach it will be necessary to wait for a link of the results obtained with the properties of real materials. R. Eisenschitz, England

4007. Broer, L. J. F., Laminar flow of a visco-elastic fluid (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3**, 205–209.

Defining a "Maxwell body" as a material for which the rate of strain is a linear function of the stress and its time derivative, the hydrodynamical equations of motion are generalized in such a way that they apply to Maxwell bodies. Considering periodic movement of small amplitude, these equations can be solved by utilizing the corresponding solutions of the Navier-Stokes equations. It is merely necessary to substitute in the latter a complex, time-dependent quantity for the coefficient of viscosity. Solutions appropriate to steady flow can also be derived from the corresponding solutions of the Navier-Stokes equations. In this case an iteration method is applied in which the inertial and the elastic terms are considered as small corrections.

R. Eisenschitz, England

4008. Ericksen, J. L., Hypo-elastic potentials, *Quart. J. Mech. appl. Mech.* **11**, I, 67–72, Feb. 1958.

Author considers hypo-elastic materials with constitutive equations in cartesian tensor notation,

$$\dot{t}_{ij} - t_{ik}\omega_{jk} - t_{jk}\omega_{ik} = B_{ijkm}d_{km} \qquad [1]$$

where $2d_{km} = v_{k,m} + v_{m,k}$, $2\omega_{ij} = v_{i,j} - v_{j,i}$, and v_i is the velocity vector, t_{ij} the stress tensor. A "dot" denotes the material derivative and B_{ijkm} is a tensor invariant of t_{ij} such that $B_{ijkm} = B_{jikm} = B_{ijmk}$. Conditions necessary and sufficient are derived for the existence invariants ϕ and ψ of t_{ij} such that

$$\dot{t}_{ij}d_{ij} = \dot{\phi}\dot{\psi}$$

holds whenever t_{ij} and $v_{i,j}$ satisfy [1].

A. E. Green, England

4009. Vreeland, T., Jr., Wood, D. S., and Clark, D. S., The basal slip in zinc under static and dynamic loading, *J. Mech. Phys. Solids* **6**, 2, 111–126, 1958.

The static and dynamic shear behavior of two purities of zinc single crystals, viz. 99.99 and 99.999% purity, is investigated. All the crystals tested were in the form of cylindrical rods with the (0001) crystallographic direction parallel to the rod axis. The static-shear-stress versus shear-strain relations are obtained from these tests. The dynamic tests were conducted by suddenly stopping (within a period of about 25×10^{-6} sec) one end of the crystals which were moving in the slip direction with various velocities. The resulting waves of plastic shear deformation which propagate from the stopped ends of the crystals toward the free ends are analyzed. The analysis is based upon the assumption that elastic strains may be neglected in comparison with the plastic strains.

The use of the results of this analysis in conjunction with measurements of the permanent lateral deflections of the crystals resulting from the dynamic tests leads to the determination of dynamic-shear-stress versus shear-strain relations. The results of this study show that the stress required to produce a given permanent basal shear strain in single crystals of zinc is considerably greater under the dynamic conditions employed than under static conditions. This stress decreases with increasing temperature.

From authors' summary by R. G. Boiten, Holland

4010. Matildi, P., Experimental results of bending experiments on beams made from inelastic material (in Italian), *G. Gen. civ.* **95**, 6, 434–466, June 1957.

Author does not agree with the classical theory of inelastic bending based on the use of (σ, ϵ) diagrams of the material obtained by tension and compression tests. He proposed in a preceding paper [*Atti Ist. Sci. Costruz., Univ. Bari* no. 2, 1956] another procedure which uses as a basis a (σ, ϵ) diagram derived directly from bending tests.

The present paper describes a series of tension, compression, and bending experiments on prismatic and cylindrical specimens, undertaken to compare the two foregoing methods. The conclusion of the author is that the method proposed by himself gives a much better agreement with his experiments.

Ch. Massonnet, Belgium

4011. Hill, R., Stability of rigid-plastic solids, *J. Mech. Phys. Solids* **6**, 1, 1–8, 1957.

Author analyzes mathematical basis for comparing criteria for stability and for uniqueness. The stability criterion under dead

loading is derived. Significance of broader uniqueness functions is analyzed. Results of analysis are applied to compression of strut to give conditions for stability and to show differences in critical hardening-rate for stability versus uniqueness criteria.

H. I. Fusfeld, USA

4012. Bland, D. R., The associated flow rule of plasticity, *J. Mech. Phys. Solids* **6**, 1, 71–78, 1957.

Author states in his summary, "The workhardening and linearity hypotheses introduced by Drucker are logically equivalent to the hypotheses of the existence of the plastic potential and of its identity with the yield function. Since neither of these sets of hypotheses is deducible from established physical laws, the author suggests that they are alternative statements of a new physical law." It is true that my mechanical-thermodynamic *definition* of stable workhardening and perfectly plastic time-independent materials leads to convexity of all yield surfaces and generalized normality of the plastic strain increments. Also conversely, convexity and normality require that when an external agency adds forces to an already loaded elastic-plastic body the work done by the external agency is positive. However, the two approaches are not fully equivalent and as a result the author is led to some reasonable but still added regularity conditions at singular points of the yield surface.

The mechanical-thermodynamic postulate has a two-fold advantage. It is predictive, as for example in connection with slip theory of Batdorf and Budiansky. If over-all plastic deformation is computed from simple slip on some or all planes and if such slip follows a hardening law, the resulting yield surface for a single crystal or a polycrystalline metal must be convex. The second advantage is that the postulate is essentially in the language of irreversible thermodynamics and is suggestive for time-dependent materials. Nevertheless, the flattering conclusion of a new physical law requires qualification. Unstable materials, such as mild steel at the upper yield point, do exist and true time-independence does not. My statement about positive work by the external agency merely defines a very extensive class of stable materials. Only in this narrow sense can it be considered a law rather than a postulate or definition.

D. C. Drucker, USA

4013. Boyce, W. E., and Prager, W., On rigid workhardening solids with singular yield conditions, *J. Mech. Phys. Solids* **6**, 1, 9–12, 1957.

Authors extend Hill's uniqueness theorem and extremum principles for rigid work-hardening solids with regular yield condition [AMR **10** (1957), Rev. 4013] to materials with singular yield conditions.

W. T. Koiter, Holland

4014. Rovinskii, R. M., and Lyuttsau, V. G., Influence of a preliminary plastic deformation on the relaxation of stresses in pure metals (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 6, 57–60, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1293.

The results are given of experiments on the relaxation of aluminum (99.99%) and copper (99.92), preliminarily deformed by elongation up to a different magnitude for the residual deformation. Curves constructed for the relaxation of an elastic deformation in terms of logarithmic coordinates led to the obtaining of a rectilinear relation, provided that along the axis of the abcissae the logarithm of time is plotted, while along the axis of the ordinates, the logarithm of log (e_0/e), where e_0 is the preliminary deformation. The declination from normal was examined in the initial portion of the curve. Relying on these results and those obtained earlier by them [title source, 1952, no. 10], the authors deduce that the process of stress relaxation is expressed by the equation for an elastic-plastic process $\sigma = \sigma_0 \exp(-k_1 t)^p$. The index p for the plasticity of aluminum and copper decreases with the increase of the preliminary plastic deformation. The relative speed of relaxation of stress k_1, on the contrary, increases with the increase of the preliminary plastic deformation. On the basis of the indicated previous works the increase in k_1 is explained by the development of microstresses, and the decrease in p by the granulation breakdown of the blocks.

P. O. Pashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4015. Bagryanskii, K. V., Investigation of elastic plastic deformations in seams in the process of being welded (in Russian), *Sb. statei Mosk. vyssh. tekhn. uch-shcha* **37**, 97–107, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1259.

The case was examined of the appearance of deformation when a thin plate was cooled after the building up on it of metal by hot rolling along its axis. At the same time a form of calculation was given permitting the determination of the elastic and of the plastic deformation. The computations were evolved while taking into consideration the temperature deformations and the effect of bonding. For the calculation of the given case a determination was made by experiment of the free temperature deformation on a strain gage and the relative deformation of the metal when it was cooling in the welding bath, both longitudinally and transversely. At the same time the temperatures were recorded. A special apparatus was evolved for measuring the deformation of the metal when cooled from temperatures of 1350–1400°. The deformator was built on the basis of an indicating head with tungsten probes. The feet of the apparatus were immersed in the molten metal of the heating bath and during the cooling process coalesced with the metal and were deformed as the metal of the seam was deformed, which was recorded simultaneously with the temperature on the drum of an oscillograph. Using the developed method and apparatus the transverse deformations were investigated when butt-welding plates "sotka" 36.402cm in length and 12mm thick, with different widths. With the help of the indicated method and appliance it was possible to estimate the influence of some technical factors and details of construction of the apparatus on the amplitude and nature of the deformations in the metal of the seam. The investigation was carried out in the laboratory for welding MVTU.

G. A. Nikolaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4016. Haythornthwaite, R. M., Plastic behavior of beams with elastic end constraints (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles 1957; **8**, 59–64.

Rigid plastic theory has shown that axial forces developed in a beam, subjected to end constraints, have a profound influence upon ultimate load-carrying capacity. These axial forces during initial loading give rise to a considerable increase of load-carrying capacity. In reversed loading, however, the load-carrying capacity may be well below the original limit load.

The paper describes the procedures and results of four tests carried out with steel beams of various depths. The resulting diagrams of loads versus deflections of the clamped beams prove that the expected drop in load-carrying capacity is restricted to a limited period of the loading cycle. The high influence of rigid end clamping upon the collapse load is shown experimentally.

A. Slibar, USA

4017. Geniev, G. A., Theory of settled movement of a friable medium (in Russian), Investigation of endurance, plasticity and creep in building materials, Moscow, 1955, 45–46; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2278.

The condition of a friable medium undergoing plane deformation, which set in when boundary equilibrium had been achieved, was investigated. A system was built up of five equations for determining the field of velocities, in which were used three equa-

tions of the theory of boundary equilibrium and the condition of incompressibility of the medium. The fifth equation was introduced in two variants. In the first case it was assumed that the lines of current coincide with the direction of the lines of slip; in the second a condition was introduced regarding the coincidence of the direction of maximum velocities of shear and of the direction of the lines of slip. A conversion of the system of equations obtained is given and an examination is made of the methods of calculation. It is essential to point out that the assumptions made by the author lead to the collapse of the condition of the coincidence of the principal axes of stresses and the principal axes of velocities of deformations. The problem being investigated for the determination of the field of velocities of a friable medium was studied (originally) by A. Yu. Ishlinskii [*Ukr. matem. Zh.* **6**, no. 4, 1954]. V. G. Berezantsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4018. Tavasenko, I. I., Conditions of plasticity and endurance of metals, *Nauch. tr. Leningr. inzh.-stroit. in-ta* no. 23, 102–113, 1056; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2232.

A criterion is recommended for plasticity and endurance in the form of a linear dependence of the largest tangential stress on the median normal stress. It should be noted that such a criterion was proposed previously by N. N. Davidenkov [*Vest. inzh. i tekhnikov* no. 41, 1947]. Experimental data are furnished, on the basis of which the author comes to the deduction that the given criterion gives better results than the analogous condition utilizing, instead of the largest tangential stress, the values of the intensivity of the stresses. A better defined criterion is also proposed to indicate the influence of the form of deviator of the stresses. In the end the following relation is obtained

$$t_1 = t_{max} + ks + ls \sin \pi\mu$$

where t_{max} is the largest tangential stress, s the mean new stress, μ Lode's parameter for the stresses, t_1, k and l constants. The correction, describing the last component of the formula, is introduced by the author on the basis of the known diagram of the destruction of similarity between the forms of deviators of stresses and deformation.

The considerations which guide the author remain incomprehensible. To establish by a speculative approach the link between the destruction of similarity of the deviators and the resistance to deformation is impossible, and the author produces no experimental substantiation. Yu. I. Yagn

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4019. Eimer, Cz., The foundations of the theory of creep of statically indeterminate prestressed structures (in Polish), *Rozprawy Inz.* **5**, 3, 421–458, 1957.

The foundations of the theory of creep of statically indeterminate prestressed structures are presented in a general manner, i.e. by considering the nonhomogeneity of the element and the statical indeterminacy of the structure as a whole, as well as retarded deformations independent of creep, such as concrete shrinkage and thermal deformations.

Due to the difficulties of the problem it was examined hitherto by means of simplified methods only. The present author succeeded in obtaining a more exact solution.

Considerations are based upon the Volterra-Boltzmann general theory of linear creep. They lead to a system of linear integral equations, enabling the determination of the redundant quantities in function of time. In order to simplify the results for practical use, author, using the exact solution, considers the principal ways of simplifying the assumptions of the theory, in particular:

(1) The simplification of the equations of internal statical indeterminacy; this can be used in the case of a prestressing reinforcement, concentrated at one level.

(2) The simplification of the equations of external statical indeterminacy; this can be used in the case of continuous beams.

(3) The avoidance of the internal statical indeterminacy by replacing the nonhomogeneous system with a homogeneous one (the case of free slip of the cable in its channel being included).

(4) The simplification resulting from replacing the integral relations by differential relations.

The paper does not contain solutions of practical cases; the author announces these will constitute the subject of a separate paper. S. Kaufman, Poland

4020. Bazilevich, A. I., The principles of resistance during turbulent movement of two-phase liquids (in Russian), *Nauch. zap. L'vovsk. politekhn. in-ta* no. 31, 114–126, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2088.

The results of R. I. Shishchenko's works ["Hydraulics of clay solutions," Azneftizdat, 1951] on the determination of a generalized Reynolds number for a viscous-plastic flow, with different ways of finding the velocity gradient, are introduced. Here also are cited the formulas of different authors for ascertaining the loss of pressure in the flows of clay solutions, sewerage sludge, pulps and peat water mixtures. I. I. Orlov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4021. Popper, B., and Reiner, M., The application of the centripetal effect in air to the design of a pump, *Brit. J. appl. Phys.* **8**, 12, 493–494 (Notes and News section), Dec. 1957.

Failure, Mechanics of Solid State

(See also Revs. 3938, 3982)

4022. Hardrath, H. F., and Leybold, H. A., Further investigation of fatigue-crack propagation in aluminum-alloy box beams, *NACA TN* 4246, 12 pp. + 2 tables + 9 figs., June 1958.

Results are presented for several designs of built-up box beams tested at one load level. Stress redistribution during the tests was studied to aid in interpreting the results. Parameters which varied were the material of construction, mode of connecting stringers to cover skins, ratio of stringer area to skin area, and location of rivets with respect to line of crack propagation.

From authors' summary

4023. Carter, T. L., Effect of fiber orientation in races and balls under rolling-contact fatigue conditions, *NACA TN* 4216, 10 pp. + 2 tables + 20 figs., Feb. 1958.

The rolling-contact fatigue spin rig was used to study the interrelations of fiber orientation and fatigue. In both balls and races, a concentration of fatigue failures was observed in regions with the highest angle of intersection of fiber flow lines with the surface. Also, in races, poorer fatigue life was observed with increasing fiber orientation angle. Each of the ten ball materials studied showed a greater than normal tendency to fail in the polar or end grain areas. From author's summary

4024. Underwood, E. E., Marsh, L. L., and Manning, G. K., Creep of aluminum-copper alloys during age hardening, *NACA TN* 4036, 36 pp. + 5 tables + 29 figs., Feb. 1958.

The interrelation of aging during creep and of creep during aging has been studied in polycrystalline aluminum alloys containing 1 to 4% copper. Experimental procedures included interrupted creep tests, tensile tests of crept specimens, quantitative metallographic determination of the percentage of precipitation during creep, hardness measurements on unstressed and stressed aged alloys, x-ray studies of deformation in the crystalline lattice, and microscopic examination of the surface-deformation markings.

From authors' summary

4025. Carter, T. L., Effect of lubricant base stock on rolling-contact fatigue life, *NACA TN* 4161, 16 pp. + 1 table + 5 figs. Feb. 1958.

Five different base-stock fluids, a methyl silicone, a mineral oil, a glycol, a sebacate, and an adipate, were tested as lubricants in the rolling-contact fatigue spin rig using groups of air-melt M-1 tool-steel balls at 100F. Other test conditions such as lubricant viscosity at test temperature and ball loading were held constant. Differences were observed in the ball fatigue lives produced with these lubricants. Lubricants whose viscosities were increased the most by pressure produced the longest fatigue lives. No differences were observed in chemical or metallurgical effects or in failure type. From author's summary

4026. Hyler, W. S., Popp, H. G., Gideon, D. N., Gordon, S. A., and Grover, H. J., Fatigue behaviour of aircraft, *NACA TN* 4137, 25 pp. + 9 tables + 27 figs., Jan. 1958.

This investigation involved a study of the correlation of composite structural fatigue behavior, basic material, and simple-element behavior. Fatigue and related static tests were made on aluminum-alloy box beams and I-beams and also on elements simulating key failure locations in the two beams.

From authors' summary

4027. Thompson, N., and Wadsworth, N. J., Metal fatigue, *Advances in Physics* **7,** 25, 72–170, Jan. 1958.

The purpose of the present paper is to review the current position in respect of some of the basic problems; if it succeeds in arousing a more general interest in such problems, some part of the writers' objectives will have been achieved. Potential readers are envisaged as being physicists interested in the strength of metals rather than engineers or metallurgists interested in physical speculations. This idea has influenced the content not a little; it has been thought proper, for example, to explain what is meant by a "rotating cantilever machine" but to assume that the difference between an edge and a screw dislocation is already known. Part I sets out very briefly what might be called the background of experimental techniques. Part II summarizes some of the very large number of experimental results, while part III discusses, briefly, some of the current ideas on the interpretation of these results. From authors' summary

4028. Carter, T. L., Effect of temperature on rolling-contact fatigue life with liquid and dry powder lubricants, *NACA TN* 4163, 19 pp. + 2 tables, + 13 figs., Jan. 1958.

The fatigue life of AISI M-1 tool steel was determined at temperatures of 100, 250, and 450 F with di(2-ethylhexyl)sebacate lubricant and at 450 F with dry powder lubricants. With the sebacate, lubricant life decreased with increasing temperature. At 100 F a suspension of molybdenum disulfide in polyalkylene gylcol produced a definite limit on fatigue life because of stress-corrosion penetration to the subsurface zone of high shear stress. The lowering of fatigue life with dry powder lubricants at 450 F appeared to be due to the lubricant particles acting as stress raisers localized in the bands of pure rolling within the contact zone. From author's summary

4029. Frost, N. E., and Dugdale, D. S., The propagation of fatigue cracks in sheet specimens, *J. Mech. Phys. Solids* **6,** 2, 92–110, 1958.

Fatigue tests have been carried out on mild steel, aluminum-alloy and copper-sheet specimens containing a small central slit. Measurements of the growth of the fatigue cracks initiated by the slit were made as the test proceeded. In some of the mild steel specimens a plastic zone was visible around the growing crack. Measurements of the plastic zone were made whenever possible and these showed that a state of geometrical similarity existed between the crack length and plastic zone dimensions.

For low stresses the crack growth was sometime erratic, but while the growth was steady and the over-all crack length less than about one eighth of the specimen width it was found that the rate of growth was proportional to the current crack length. The effect of mean stress is discussed.

From authors' summary

4030. Lingo, J. R., The detection of fatigue cracks in specimens under dynamic loading, *Aircr. Engng.* **29,** 345, 334–342, Nov. 1957.

Paper discusses a method of detecting fatigue cracks in light alloy and steel specimens under dynamic loading.

Essentially, the method comprises the cementing of an electrical circuit in the form of a fine insulated copper wire to the surface of the specimen under test.

When a fatigue crack crosses the wire it breaks it in a static manner, a relay is actuated and in turn some form of indicating device such as a warning lamp or bell; alternatively, the operation of the relay may be employed to stop the fatigue testing machine and thereby prevent the failure from continuing.

It is envisaged that the method will, with further development, ultimately prove a satisfactory means for giving warning of impending fatigue failures in aircraft components and structures under laboratory or flight conditions up to about $N = 10 \times 10^6$ cycles.

The system of fatigue crack detection developed has proved to be an extremely versatile tool in the laboratory and a useful adjunct to the more conventional and commonly used "test and inspect" procedures.

In providing warning of the existence of a fatigue crack it enables a visual or aural warning to be given to the operator, or it may be indirectly employed to stop the fatigue testing machine.

By this means an immediate inspection subsequent to the initiation of the fatigue crack can be carried out and the location of the crack identified before catastrophic failure occurs; costly specimens such as a complete aircraft wing structure can be repaired and retested, and statistical data on the life of components and structures between crack initiation and ultimate fracture may be compiled, In addition, the detector, if coupled to appropriate circuitry, provides a potentially useful warning device for use in flight.

Early work was carried out in a Losenhausen U.H.P. 50-ton universal testing machine at 666 cpm using fatigue specimens of all types of aircraft components being tested under a current fatigue program.

Not one known fatigue crack formed within the specimens tested failed to be detected and none of the cracks detected propagated more than about 0.05 in. after having been detected, with one notable exception, a propeller hub in chrome-plated S11 steel, in which case the highly finished surface offered a poor key for the cement bonding the crack detector.

These results encouraged the continuation of the work on a more controlled basis.

Plain and notched specimens in light alloy material to specification D.T.D. 610 were tested in order to determine if the means of detection, shown to be satisfactory on the limited life specimens tested initially, would be reliable at high endurances and in particular for use under flight conditions.

The final results suggest that the types of fatigue crack detector considered form a suitable means by which to give warning of the impending failure in aircraft components and structures under laboratory or flight conditions up to about $N = 10 \times 10^6$ cycles.

To provide a background some of the existing work which covers variations of the method, each designed to achieve basically the same results, is first discussed. From author's summary

4031. Carter, T. L., Effect of lubricant viscosity on rolling-contact fatigue life, *NACA TN* 4101, 14 pp. + 2 tables + 5 figs., Oct. 1957.

The rolling-contact fatigue spin rig was used to obtain life data for groups of steel balls lubricated with a series of paraffin-base mineral oils of varying viscosity. AISI M-1 balls were tested at 100 F and a calculated maximum compressive Hertz stress of 725,000 psi. A continuous trend toward longer life with higher lubricant viscosity was observed. Life varied approximately as the 0.2 power of lubricant viscosity.

From author's summary

4032. Ipatov, N. K., Method of testing for fatigue by means of repeated bending impacts (in Russian), *Zavod. Lab.* **20**, 8, 970-971, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1301.

A machine is used to determine the endurance of metals when subject to repeated bending impacts; these impacts are carried out on a test piece by a falling weight from a specified height, the weight being ~ 4 kg. The number of blows struck by the drop weight endured by the test piece up to the point of destruction was accepted as the criterion of dynamic endurance strength. Samples of steel, case-hardened to different depths, with 0.16 to 0.23 carbon content, were tested. The resistance to repeated blows decreases in proportion to the increase in depth of the hardening of the specimens and the carbon content of the hardened steel; double hardening as compared with the normal procedure increases, while a low-temperature tempering after hardening causes deterioration of the resistance of the case-hardened steel to repeated blows. Thus an opinion on the factors governing the fatigue endurance when the test pieces are loaded with cyclic static deflection cannot be developed on a mechanical basis to account for the behaviour of the components working in conditions of dynamic loading. M. A. Babichev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4033. Antonovich, A. V., Automatic recording system for measuring the duration of oscillation processes (in Russian), *Zavod. Lab.* **21**, 6, 728-731, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1386.

An apparatus is described permitting the recording of the duration of oscillation processes in some special cases of laboratory investigations; in particular, when testing metallic samples or components for fatigue, continued to the destruction point. The transmitter of the apparatus consists of a metallic plate placed near the oscillating component, and constituting with it a capacitor with an air dielectric. The oscillation of the sample gives rise to change in capacitance, which, in its turn, causes current pulsations in the transmitter circuit. The pulsations are amplified by means of a 3-stage amplifier, and are recorded on a special self-recording device; from this record it is possible to establish the instant the oscillations of the component stop, or the instant of the component's destruction. The winding of the clock mechanism of the self-recording instrument is designed for a 7-day period. The apparatus can serve simultaneously for several appliances. I. I. Blekhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4034. Vagapov, R. D., Dimentberg, F. M., and Serensen, S. V., Problems regarding the dynamic endurance of rotors of turbo-generators (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 9, 65-106, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1227.

An estimate is made of the part played by the rotor of a turbo-generator when passing through the critical speeds and of its interaction by vibration with the flexible supports of the generator. With the aid of an experimental curve, obtained by means of a mechanical vibrator, the spectrum of the critical speeds of the rotor was determined, taking into account the dynamic properties of its supports. The steady oscillations of a rotor with constant section were examined; the rotor had two different principal rigidities and loaded by gravity; a study was also made of the influence of the oscillating movement of the supports on the deformation of the rotor. A theoretical analysis, combined with measurements on models and working machines, made it possible to establish a qualitative and quantitative conception of the change in stresses in the rotor when going through the critical speed. The analysis of the stationary oscillations was carried out while considering the rigid strength, taken to be proportional to the first degree of deformation. The distribution of stresses in the most dynamically stressed parts of the rotor, situated in the center, was investigated. A valuation of the supporting power was made on the basis of the data on the distribution, as variables, of the stress components, evoked by the gravity of the rotor, and also as constants of the components, specified because of centrifugal forces, uneven heating of the rotor, and residual stresses due to thermal and mechanical working. An estimate is given for the endurance of the rotor in relation to its fatigue strength. In addition, an investigation was made of the influence of absolute dimensions and of irregular distribution of stresses on the supporting capacity of members and test samples, and, further, an estimate was obtained for the supporting capacity of the rotor in conjunction with concentration of stresses, absolute dimensions, and condition of the surface layer. It was shown that the application of the results obtained, for determination of the safety factor for endurance of definite types of rotors, testifies to the insufficient accuracy of the results given by the usually applied methods of calculation. N. N. Babaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4035. Danilov, L. V., Determination of the cyclic ductility at the fatigue limit and its application in endurance calculations for the components of machines (in Russian), Rascheti konstruirovanie detalei mashin, Moscow, Mashgiz, 1956, 33-48; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1308.

Article contains some considerations on the so-called nature of cyclic ductility, introduced first by I. A. Oding, and determining, in the author's opinion, the ability of materials to resist variable loads. The article repeats the earlier published attitude taken by I. A. Oding [*Vestn. mashino stroeniya*, no. 1, 1948] without any essential supplementary explanations or critical comments.

M. P. Markobets

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4036. Uryu, T., Effects of post-heating and electro-polishing on fatigue strengths of 70 : 30 brass and electrolytic copper specimens, *Rep. Res. Inst. appl. mech. Kyusbu Univ.* **5**, 19, 107-113 (Short Notes), 1957.

4037. Weinberg, J. G., and Bennett, J. A., Effect of crystal orientation on fatigue-crack initiation in polycrystalline aluminum alloys, *NACA TN* 3990, 21 pp., Aug. 1957.

4038. Foster, B. K., The propagation of fatigue damage measured by periodical polishing, *Aircr. Engng.* **24**, 341, 211-215, July 1957.

4039. NACA Subcommittee on power-plant materials, Cooperative investigation of relationship between static and fatigue properties of wrought N-155 alloy at elevated temperatures, *NACA Rep.* 1288, 35 pp., 1956.

[See AMR **8**, Rev. 3402]

4040. Isibasi, T., On the branch point of notched fatigue specimens, Proc. Sixth Japan. nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 71–74.

4041. Nakanishi, F., Endurance limits of solid and hollow cylinders under torsion, Proc. Sixth Japan. nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 75–78.

4042. Welsh, N. C., Frictional heating and its influence on the wear of steel, *J. appl. Phys.* **28,** 9, 960–968, Sept. 1957.

High frictional temperatures during the dry or imperfectly lubricated rubbing of steel produce gross structural changes and intense hardening of the surface layers. In consequence of these changes the wear-time curve shows a marked inflection, the wear rate of soft steel on soft steel diminishing by more than an order of magnitude as the hardened skin develops. The protective layer establishes itself more readily as the carbon content of the steel increases, a feature explained by the ease with which eutectoid pearlite transforms to austenite, and thence to martensite, during the rapid temperature cycle. By simulating the hot spots during wear by the thermal action of electric sparks, the hardness change is shown to be intensified by nitrogen or carbon absorbed from the atmosphere or lubricant. From author's summary

4043. Barwell, F. T., Wear of metals, *J. Inst. Metals* **86,** 257–269, 1957/1958.

The economic consequences of wear become of greater importance as the capital per man invested in industry increases. Wear may take many forms, its nature and magnitude being dependent on a variety of factors. The most significant of these are: speed and load, geometry, lubricant, surface roughness, the nature of oxide films, and the metallurgical structure of the sub-surface regions. The presence of abrasive matter and a corrosive environment are also of considerable importance.

Certain conditions prevailing in well-known engineering applications are illustrated from current research at the Mechanical Engineering Research Laboratory. These include pitting arising from rolling contact, scuffing arising from sliding contact, fretting corrosion due to vibratory motion, and the effect of oxygen on friction and surface damage during simple sliding. It is concluded that metallurgical structure may have a great effect in determining the wear-resistance of materials.

From author's summary by T. J. Dolan, USA

4044. Cataldi, H. A., Cheng, C. F., and Musick, V. S., Investigation of erosion and corrosion of turbine materials in wet oxygenated steam, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-134, 12 pp.

Steam from the boiling water reactor of the Dresden Nuclear Power Station will enter the turbine at 869 psia and 525 F with ½% moisture and with oxygen concentration higher than normal in power-plant practice. This paper discusses a series of preliminary laboratory tests evaluating the resistance of various materials for turbines and related components to erosion (impact, washing, wire-drawing) and corrosion (weight loss, pitting depths, crevice, and galvanic attack) in wet, oxygenated steam. Materials tested included carbon and low-alloy steels and cast iron, austenitic and ferritic stainless steels, Monel, cupronickels, leaded bronze, Stellite, and Ductile Ni-Resist No. 3. It is concluded that, with proper design, conventional materials may be used in the Dresden turbine except in a few critical areas.

From authors' summary

4045. Gough, V. E., and Shearer, G. R., Front suspension and tyre wear, *Instn. mech. Engrs. Auto. Div.*, no. 6, 171–218, 1955/1956.

Tire wear depends very largely on the cornering forces which tires are called upon to develop. A consideration of the effects of front suspensions on tire wear involves a discussion of the effects of suspension and steering geometry on the slip angles developed at the two front wheels.

The paper explains why a tire, developing a cornering force, wears, and shows that the rate of wear increases rapidly with increase of cornering force. It then proceeds to a brief history of types of suspension. The two types predominantly in use are examined for such effects as changes of alignment and of track, which can cause the tires to operate under slip angle conditions.

The location of the track rod and the rigidity of the steering linkage are shown to be of importance. Such trends in vehicle construction which have improved stability have tended to increase front tire wear in relation to that of rear tires. Paper attempts to deal with matters of principle rather than of practical detail of design and construction, but it is shown that quite small changes of practical detail can at times have significant effects on tire slip angles, and hence tread wear.

From authors' summary

4046. Hunt, J. B., Brittle fracture of mild steel in torsion, *Engineer, Lond.* **184,** 4770, 173–174, Aug. 1957.

In the present investigation, impact tests have been made on mild-steel specimens in torsion at low temperatures in order to study the variation in stress-strain characteristics as brittle fracture conditions are approached. It was found that a uniform elasto-plastic twist existed and that this twist became a maximum when the over-all ductility began to decrease. Torque-twist curves with a negative slope after yield were obtained.

From author's summary

4047. Thomas, J. L., Design influence on residual stress and brittle fracture, *Welding J.* **36,** 8, 387s–392s, Aug. 1957.

Paper discusses the relationship of residual stresses to brittle fracture as experienced in railroad car components; also, it points out the important influence of design in alleviating the difficulty.

From author's summary

4048. Kochendorfer, A., and Scholl, H., The tendency to embrittlement of steels as dependent on the stress condition and temperature, *Stahl Eisen* **77,** 15, 1006–1018, July 1957.

Paper discusses: Shapes of test bars examined and their multiaxiality figures; yielding and rupturing stress as dependent on the multi-axiality figure and temperature; representation of this dependency in three-dimensional diagrams; brittle fracture temperature and transition temperature as dependent on the stress condition; arrangement of the results of notched bar impact tests; conclusions to be drawn for testing the tough or brittle fracture behavior. From authors' summary

4049. Edeleanu, C., and Snowden, P. P., Stress corrosion of austenitic stainless steels in steam and hot-water systems, *J. Iron Steel Inst. Lond.* **186,** 4, 406–422, Aug. 1957.

Austenitic stainless steels are frequently used in plant involving high-temperature water and steam. Service experience shows that such material is very satisfactory for these applications except for an occasional case of stress-corrosion cracking. In view of the present use of austenitic steels in advanced conventional power plant, and their proposed use in certain types of nuclear power reactors, it was necessary to investigate the conditions responsible for this type of cracking, since failures cannot be tolerated in either of these applications.

The present work shows that cracking can be rapid in water and steam systems, but only under somewhat specific conditions. Impurities must be present and the pressures and temperatures must be such as to allow the formation of a layer of concentrated electrolyte on the steel surface. From authors' summary

4050. Hoke, J., and Eberle, F., Oxidation of superheater materials by high-temperature steam, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-175, 10 pp.

In order to obtain information on the corrosion resistance of superheater materials to steam under actual service conditions, six low- and medium-alloy materials were exposed at various temperature levels ranging from 950-1250 F for 7323 hr during the operation of an experimental superheater. The results indicate that there is a narrow temperature range over which oxidation begins to increase rapidly. This transition temperature is approximately 1050 F for carbon steel and 1100-1150 F for the low-alloy steels. The addition of up to 5% chromium does not add materially to the long-time oxidation resistance of low-alloy steel, but a chromium content of 9% markedly increases the temperature at which oxidation becomes serious.

From authors' summary

Material Test Techniques

(See Revs. 3944, 3945, 4009)

Mechanical Properties of Specific Materials

(See Revs. 3940, 3980, 3984, 3987, 4014, 4018, 4024, 4034, 4036, 4037, 4039, 4046, 4049, 4054)

Plasticity, Forming and Cutting

Book—4051. Biernawski, W., Theory of cutting of metals, Warsaw, Poland, National Scientific Publications, 1956, 455 pp., 290 figs., 60 tables, 287 ref. 34.70 zloty.

This work is unique in its kind and treats the theory of metal-cutting from the physical side. For an American reader the book is extremely interesting because the described development of the knowledge of cutting of metals considers very broadly the Russian contributions, rather unknown in this country. (About half of listed references are Russian.)

The author, a recently deceased professor of the Mining and Metallurgical Academy, Cracow, and head of the Polish Institute for Machine Tools and Machining of Metals, attempted to paint a true picture of the world development of the art. As major contributors he sees Russia, Germany and United States, but he discusses also the contributions of England, France, Poland, Czechoslovakia, Hungary and Finland. His work reaches 1953, while a second edition is already prepared, which includes the development until his death in 1957.

About 20% of the text discusses the geometry of cutting edge and of the removed layer. The remaining 80% deals with the physical foundations of machining knowledge, based on the theory of plasticity.

The particular chapters of the latter part deal with plasticity and wear, cutting stress analysis, chip formation and forces, cutting heat and temperatures, gradual progress of tool wear, tool life factors, surface finish, machinability and basic economics of machining.

The Polish successors of the author requested the reviewer to look for an editor of an American version of this work, intended as an international contribution. A. Niedzwiedzki, USA

4052. Rozenberg, A. M., Two methods for the theoretical calculation of cutting forces (in Russian), Peredov. tekhnologiya mashinostr., Moscow, Akad. Nauk SSR, 1955, 392-406; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 950.

Author recommends the following two methods for determining cutting forces, based on the concept that cutting is a process of uniaxial deformation proceeding (1) from the hypothesis of the equality of the specific work of deformation when cutting and compression are in operation [*Ref. Zh. Mekh.* 1954, Rev. 4911; 1955, Rev. 5164] and (2) from the hardness of the removed chips (reckoning that the hardness characterizes the strength of the material being deformed and that the workhardening can be disregarded). In the abstractor's view, both the methods appear to be crude and theoretically insufficiently substantiated, inasmuch as in cutting a complex stressed condition arises in the metal being worked on. It is obvious, for instance, that the stress field created when testing for hardness is appreciably different from the stress field created during cutting. G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4053. Nekrasov, S. S., Elements of the theory of the strength of brittle materials to cutting (in Russian), *Nauch. tr. po. vopr. gorn. dela. Mosk. gorn. in-ta,* no. 15, 63-93, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 951.

For determining the maximum value of the principal component of the cutting force P author proposes to use I. Ya. Shtaerman's formula for pressing into an elastic semiplane by means of the axial force of a punch with rounded edges [I. Ya Shtaerman, "Contact problem of the theory of elasticity," Gostekhizdat, 1949]. In so doing it is assumed that the principle of distribution of the contact pressure along the front cut of the cutting tool is nearly equal to one half of the symmetrical curve on the surface of contact of the punch with the semiplane (the substantiation of this situation on pp. 65-68 does not appear convincing). In this way, author obtains formula [8] linking the cutting force P with the maximum pressure p on the surface of contact. For the determination of p author proposes to use Prandtl's solution for the compression of a symmetrical blunt wedge [see, for instance, A. A. Il'yushin, "Plastichnost," Gostekhizdat, 1948], having generalized it for the case of compression of an unsymmetrical wedge. This generalization is incorrect. On the surface of contact the pressure must be constant, inasmuch as the field of lines of slip at the platform of contact consists of two rectilinear families. Meanwhile, author obtains at point A of the surface of contact (Fig. 4) pressure $p_A = \sigma_s$, while for point B pressure $p_B = 4.2\,\sigma_s$. On the basis of the theorem on boundary equilibrium, giving an evaluation of the carrying capacity above, it is easy to be convinced that the pressure on the whole platform of contact should be $p = \sigma_s$. The theoretical considerations are set out with lack of clarity and give arise to doubts. For instance, is there any basis for applying to brittle materials such as coal the criteria of plasticity of Tresca-Saint-Venant? It would be more proper to rely on the hypothesis of Kulon-Mor. The concepts concerning the "obstructed" cutting remain unintelligible to the abstractor. G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4054. Voskresenskii, S. A., The regularity of the process of compression of shavings when wood is simply cut across the fibers (in Russian), *Nauch. tr. Mosk. Lesotekhn. in-ta* no. 4, 86-97, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1357.

It is assumed that, in the process of cutting, the shavings undergo deformation due to elastic compression and shear. Plastic deformation is not considered. Comparisons with experiments are not carried out. G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4055. Okushima, K., and Asaka, N., The failure of process of high speed steel tools on cutting of mild steel, Proc. Sixth Japan. nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 181–185.

4056. Nakazaki, M., The cutting force of three-dimensional planing operations, Proc. Sixth Japan. nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 175–180.

4057. Lianis, G., and Ford, H., Control equations of multi-stand cold rolling mills, Instn. mech. Engrs., Prepr., 18 pp., 1958.

External disturbances, such as coiler tension, roll gap, roll speed and strip gage, affect the response between stands in cold-mill operation. Authors derive control equations governing the response and thus describe the roll force, roll torque, and slip. These equations turn out to be numerous and of the partial derivative form, difficult to evaluate when the many possible disturbances are accounted for. Engineering simplification of these relations is claimed not feasible because of the impossibility of predicting negligibility of terms in the final result.

Authors proceed to overcome the difficulties by means of a general quantitative approach in which nomographs are used. The nomographs prepared and presented are simplified so that even the lay millsman can easily use them. Examples portraying nomograph application are included in the paper.

J. P. Vidosic, USA

4058. Konig, H., Smooth rolling, a chipless method of fine working (in German), *Z. Metallk.* **48,** 6, 366–370, June 1957.

Article reviews briefly a fine-forming process which has some advantages over cutting methods as, for example, increased hardness of the surface as compared with the hardness of the base material, and which also results in increased fatigue strength.

Processes, parameter sizes, and work-piece conditions in rolling are discussed.

The economic application and the technical value of this method is doubtful. F. Eisele, Germany

4059. Panin, V. E., Influence of the shape of the transverse section of the sample on the amplitude of axial deformation stresses under compression (in Russian), *Fiz. metallov i metalovedenie* **2,** 2, 357–360, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1273.

Following S. I. Gubkin's formulas ["Theory of treatment of metals by pressure," Metallurgizdat, 1947], an investigation was made of the difference in the influence of friction forces on the faces of samples of quadrangular and rectangular shapes in section. Results are recorded for the testing of samples 8 mm high and 144 mm² surface area. The ratio of the sides of the rectangular section equalled 4. The experiments showed that, when the samples had the same forces applied to them, the sample of rectangular section gave a larger deformation than the one of quadrangular section. Correspondingly, equal deformation of the samples would correspond to a smaller stress in the rectangular shaped section. The differences indicated in the amplitude of the stresses increase with the rise in deformation of the samples.

Yu. I. Yagn

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4060. Korolev, A. A., New formulae for determining the pressure of the metal on the roller in the hot rolling process (in Russian), Prokratnye stany i tekhnologiya prokatki, Moscow, Mashgiz, 1955, 167–182; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 925.

Assuming the presence of a zone of adherence, author obtains one differential equation for specific pressures, in place of two equations obtained earlier, on the assumption of the existence of two zones of deformation and the step-by-step transformation on the boundary of these zones. Contact forces of friction $t_x = \mu p_x$, where μ is the coefficient of friction, p_x is the specific pressure. Here, on the basis of experiments in the study $t_x = t_1[1 - (x/l)]$ is accepted, where t_1 is the contact force of friction in the section of the emergence of the metal from the rollers, l_H is the coordinate of the neutral section. New formulas were obtained for the average (along the arc of gripping) and the maximum speeds of deformation. N. S. Kurdin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4061. Ota, T., Shindo, A., Fukuoka, H., and Sugimoto, K., Some problems of wedge-shaped slip-line fields, Proc. Sixth Japan. nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 197–200.

4062. Hesse, V. W., Behaviour of rolls during rolling process (in German), *Stahl Eisen* **77,** 11, 715–727, May 1957.

4063. Magnusson, K., Influence of the viscosity of a liquid on the power requirement with wet ball mills (in Swedish), *Tekn. Tidskr.* no. 28, 227–235, May 1957.

Hydraulics; Cavitation; Transport

(See also Revs. 4087, 4144, 4182, 4183, 4203, 4222, 4223, 4224, 4308, 4316)

Book—4064. Mosonyi, E., Water power development, Vol. I: Low-head power plants, Budapest, Hungarian Academy of Sciences, 1957, 908 pp. $10.

Hungarian Academy of Sciences is credited for English edition of the Hungarian textbook, 1952–53, followed by a German edition "Wasserkraftwerke," 1956–58. Large, perfectly edited, and well-illustrated volume testifies to the heroic efforts of a small nation in contributing to general progress of science and technique. Author, the recognized authority in Europe, was able to visit USSR, India, China, N. Africa, S. America, and many European countries, and to compile a synthesis of progress around the world. Extensive bibliography reflects cooperation of many nations. Book contains: sources of energy, history and types of water power development, power estimates, general arrangement of low-head power plants, structures of diversion canals, types and parts of run-of-river power plants, the powerhouse, turbines, governors, generators, intakes, gates, screens, spiral cases, draft tubes. Many novelties are presented, like submergible plants, turbines without conventional spiral case, etc.

Translation is very correct. A few corrections are suggested: Kegum station on Western Dvina, USSR, must be Kegums station on Daugava River, Latvia; Bydin instead of Bidin. The second volume will contain high-head power plants, pumped-storage systems, and economics. S. Kolupaila, USA

Book—4065. Shvets, V. I., Investigations for hydraulic engineering (in Russian), Kiev, Gosstroiizdat Ukr. SSR, 1956, 168 pp.

This concise textbook contains field measurements in the fields of geodesy, topography, engineering geology, hydrology, structural materials, highways, property rights, economics. Special investigations for hydroelectric plants, water supply, irrigation, for storage basins are included.

S. Kolupaila, USA

4066. Richards, R. T., Air binding in large pipelines flowing under vacuum, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (*J. Hydr. Div.*), Pap. 1454, 11 pp., Dec. 1957.

Air binding is a potentially serious cause of excess head loss in water pipelines flowing under less than atmospheric pressure. This paper discusses the phenomenon of air binding and methods of control, with emphasis on the accumulation of air in sloping pipes. The specific installations described are circulating water systems of steam-electric stations, but the principles discussed are applicable to any water pumping station with similar profile.

From author's summary

4067. Khazaliya, G. Ya., The regular movement of a liquid in a tube approximating a circular cylinder in shape (in Russian), *Mat. sb.* **38,** 1, 93–106, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1874.

An approximate solution is given for the problem on the movement of an ideal liquid with axial symmetry (x – the axis of symmetry) in a tube approximating a round cylinder in shape. The problem merges with the problem of the quasi-conforming reflection of the meridian section on a rectilinear strip. The functions $u = u(x, y)$ and $v = v(x, y)$, realizing the reflection, satisfy the system of equations

$$\frac{\partial v}{\partial x} = -y\,\frac{\partial v}{\partial y},\quad \frac{\partial v}{\partial y} = y\,\frac{\partial u}{\partial x}$$

where u is the velocity potential, v is the current function. The solution of the problem is given by an approximate method by means of the generalization of one of M. M. Lavrent'ev's formulas ["Conforming reflections with additions dealing with some questions of mechanics," Moscow-Leningrad, Gostekhizdat, 1946].

V. K. Belyakova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4068. Dul'nev, V. B., An established nonuniform movement of a liquid in open nonprismatic channels with rectilinear walls (in Russian), *Izv. Vses. n.-i. in-ta gidrotekh.* **54,** 38–53, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1895.

A method is considered for the hydraulic computation of open nonprismatic channels, in which the change of width of the bottom b along the length is expressed by the linear relation:

$$b = b_0 \pm 2\,\mathrm{tg}\,\theta s = b_0 \pm as \qquad [1]$$

where b_0 is the initial width of the channel at the bottom, θ is the angle between the wall and the axis of the channel in plane. Taking into account the accepted relation [1], the basic equation of hydraulics for the established nonuniform, slowly changing movement of a liquid in open channels with a straight slope is put forward by the author in the form of:

$$\frac{dh}{ds} = i_0\,\frac{1 - \mu/r^2}{1 - N_k/N} \qquad [2]$$

where

$$\mu = 1 \mp \frac{\alpha abC^2}{gX},\quad r = \frac{K}{K_0},\quad N_k = \frac{\alpha Q^2}{g},\quad N = \frac{\omega^3}{B}$$

As the result of an investigation of the equation obtained, possible forms of curves of the free surface were developed, not only for expanding but also for contracting channels. Analogous solutions are given by the author both for channels with reverse as well as zero slants. Author introduces into the calculation the so-called boundary depth, which divides the channel according to depth into zones with curves for the fall and curves for support [see also V. M. Ovsepyan, *Sb. nauch. tr. Erevansk. politekhn. in-ta*, no. 9, 81–87, 1955]. The integration of the obtained differential equations was carried out by the method of summation, via the solution of the obtained equations by selection. In conclusion, concrete examples are given of the building of curves of the free surface, both for narrowing and widening channels.

G. A. Dzhimsheli

Courtesy Ministry of Supply, England
Translation, Courtesy Ministry of Supply, England

4069. Skiba, M. M., and Kostin, A. I., Problem of the determination of the critical depth in a trapezoidal channel (in Russian), *Sb. tr. Novocherkas. inzh.-melior. in-ta* **5,** 116–124, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1898.

To determine the critical depth of a trapezoidal channel $h_\varkappa$ by means of the formula

$$h_\varkappa = \xi_\varkappa y_{\varkappa p},\quad y_{\varkappa p} = \frac{m}{b}\sqrt[3]{\frac{\alpha Q^2}{gb^2}}$$

where Q, b and m correspond respectively to the discharge, the width of the channel at the bottom, and the coefficient of the position of the side slope, while g and α are, respectively, the acceleration of the force of gravity and the coefficient of Coriolis, it is proposed to make use of the relation

$$\xi_\varkappa = f\left(\frac{1}{1 + y_{\varkappa p}}\right)$$

To simplify calculations special curves and approximate formulas are suggested.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4070. Kravtchenko, J., Theory of second-order phenomena added to plane, nonlinear waves (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 149–156.

Experimental study of waves has progressed considerably during recent years, due to metering devices like the S. M. wave recorder, developed by Santon and Marcou. Accuracies of 0.05 mm in the depth and of 0.002 sec in the time may now be reached with the S. M. recorder. Present experimental results are accurate enough to depart from the frame of the classic linear theory of waves. Paper deals with theoretical and experimental results obtained with the equipment of the Fluid Mechanics Laboratory of Grenoble, and also gives an outline of the present status of the subject.

Paper studies the propagation of a real, plane wave in a rectangular open channel of horizontal bottom. Such a wave, even to the first order, is never simple. It is formed by a fundamental wave, accompanied by secondary phenomena such as the harmonics, subharmonics, etc. As the laws of the phenomenon are not linear, the principle of superposition of small displacements may not be applied, at least within the accuracy of the S. M. recorder. A formula for the water surface is given as the superposition of b elementary waves. This equation is exact to the second degree with respect to the camber of the fundamental wave. Some conclusions of the theory by Biésel and Miche are given. Experimental results show satisfactory agreement for the first-order wave, as formed by the fundamental wave and its harmonics. Paper ends with experimental results on waves added to the ordinary wave.

A. Balloffet, USA

4071. Numachi, F., Tsunoda, K., and Chida, I., Cavitation tests on six profiles for blade elements, *Rep. Inst. high Speed Mech., Tohoku Univ.* **8,** 25–46, 1957.

Tests of 6 hydrofoils having Clark Y, Clark YH, and R.A.F. 6 sections, each of 6 and 11.7% thickness ratio, were made to determine comparative performance characteristics under incipient and fully-cavitating conditions. Results shown include lift and drag coefficients, extent of cavitated zones, and the angle of attack for minimum drag-lift ratio as functions of cavitation number.

Comparisons are also made of the cavitation number at inception for each profile. P. Eisenberg, USA

4072. Numachi, F., Tsunoda, K., and Chida, I., Cavitation tests on Clark Y profiles of several thickness ratios, *Rep. Inst. high Speed Mech., Tohoku Univ.* **8,** 47–65, 1957.

Paper summarizes results of tests to determine cavitation characteristics of Clark Y profiles of 4, 8, 10, and 14% to extend data on effects of thickness on such profiles—obtained previously for ratios of 6 and 11.7% [see preceding review]. These results were basis for design of a new series reported in *Rep. Inst. high Speed Mech., Tohoku Univ.* **8,** 67–88, 1957 [see following review]. P. Eisenberg, USA

4073. Numachi, F., Tsunoda, K., and Chida, I., Cavitation tests on hydrofoil of simple form (Report I), *Rep. Inst. high Speed Mech., Tohoku Univ.* **8,** 67–88, 1957.

An impressive collection of results of cavitation tests on forty hydrofoil profiles for use as blade sections of ship propellers, axial flow turbines, and pumps is reported. This series is evidently an extension of the program of collection of data for cavitating hydrofoils, the first results of which were reported in previous papers [see two preceding reviews]. Objective is to achieve good performance in sections composed entirely of arcs of circles and, thus, easily machined and checked for accuracy. All profiles were of 7% thickness ratio with various leading and trailing edge configurations. Measurements of lift and drag, zones of incipient cavitation (whether suction or pressure side, leading or trailing edge), extent of cavitated regions, and onset of vibrations were made as functions of angle of attack and cavitation number. The phenomenon of lift increase and drag decrease immediately following inception (with subsequent deterioration as cavitation develops) is strikingly illustrated on these profiles. Comparisons with an "airfoil type" profile—Clark Y of same thickness ratio [see reviews cited]—show that the performance characteristics of authors' ogival sections are increasingly more favorable as cavitation number is decreased. P. Eisenberg, USA

4074. Numachi, F., Tsunoda, K., and Chida, I., Cavitation tests on hydrofoil profiles of simple form (Report II), *Rep. Inst. high Speed Mech., Tohoku Univ.* **8,** 89–107, 1957.

To examine the effect of water temperature on cavitation performance characteristics of the series of hydrofoils reported in authors' "Report I" [see preceding review], tests were made at an average temperature of 15C, the earlier tests having been run at about 20C. A slight decrease in critical cavitation number (i.e., inception point) was found, but no really significant changes in over-all performance can be discerned.

P. Eisenberg, USA

4075. Glikman, L. A., Tekht, V. P., and Zobachev, Yu. E., Problem of the physical nature of disruption by cavitation (in Russian), *Zh. tekh. fiz.* **25,** 2, 280–298, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1923.

Authors describe the experimental investigation of the process of the destruction of metals by cavitation erosion, tested on a magnetostriction vibrator. Analyses were carried out by means of metallography and x-ray. Various brands of cast iron, steel, nonferrous metals and metallic and rubber coverings were tested. The microstructure of metals exposed to cavitation erosion was studied in sections cut in the plane parallel and normal to the plane in which cavitation started. In order to clarify the mechanism of disruption, samples of the metals were exposed for periods of time to the action of cavitation, including short-time exposures. The disruption occurs first on the borders of the particles and destroys initially the least stable components of the alloys. Plastic metals before reaching the stage of brittle deformation receive some toughening due to the action of cavitation on the surface layers. The initial disruptions appear on the surface and spread to the deep layers, co-measurable with the measurements of the crystals. Exactly in the same way the thickness of the layer of toughening does not exceed a few microns. Of interest are the cases of disruption under a chromium covering of a less stable metal, when the covering is very thin. Agreement is shown with the prevalent theory of the mechanical nature of cavitation erosion and with the action of localized impacts when the microscopic cavitation pustules are compressed, upon which the application of stresses bears the character of any unilateral cycle of operations. Chemical corrosion, if compared with the intensity of cavitation destruction and corrosion of the same metals, by average depth of the destruction wrought, has secondary significance, but contributes to cavitation erosion. K. K. Shal'nev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4076. Etinberg, I. E., Influence of geometrical parameters of the blades of the working wheel on the cavitation qualities of a deflected-blade water turbine (in Russian), Gidro-turbostroenie no. 1, Moscow-Leningrad, Mashgiz, 1955, 63–80; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1917.

The results are given for the theoretical computation of the cavitation parameter of a turbine σ (corresponding to the appearance of cavitation) with the help of the dependence of σ on the relative velocity of the flow around the profiles of the blades of the working wheel at the point of smallest pressure. In order to calculate the value of the relative velocity, the method of A. F. Lesokhin is applied, which permits finding the distribution of velocities on the edges of the blade for some given values: the lifting power, the geometrical parameters of the profile and grid, and the kinematic conditions of the flow. The influence is shown of the density of the lattice $1/t$ on σ, and, commencing with $1/t \leqslant 1$, the sharp increase of σ is observed. On the basis adduced in the curve of the relation $\sigma\ (1/t)$ recommendations are put forward for the construction of blades of deflection-bladed turbines, having the minimum value for σ. The question is analyzed of the limit of the minimum value for σ. As the result of analysis of the question of the concavity of the outline for σ, the recommendation is made, with a view to prevent cavitation, to locate the minimum concavity nearer to the inlet edge of the blade outlines and to adopt profiles of small concavity. On the examples of calculations for σ for several lattices of profiles with different distribution of the maximum thickness, the recommendation is made to use profiles in which the maximum thickness is placed at a distance of 1/3 to 2/5 of the chord of the profile from the inlet edge. K. K. Shal'nev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4077. Campbell, I. J., and Thomas, G. E., Water tunnel boundary effects on axially symmetric fully developed cavities, *Aero. Res. Counc. Lond. curr. Pap.* no. 278, 14 pp. + 11 figs., 1956.

Using momentum and continuity arguments, estimates are made of effects of water-tunnel boundaries on cavitation number and drag coefficients of axisymmetric cavities. Estimates of the effects of boundary constraints on cavity configuration are made using source-sink approximations for the cavity flow. To illustrate the large effects of a fixed wall tunnel, authors' cite results for the flow about a disk normal to the stream: for a cavity of fineness ratio 10, the speed at which the cavity would be formed in a tunnel is about 35% lower than in an unbounded stream if the blockage (a^2/R^2, where a is cavity diameter, R tunnel diameter) were 4% and more than 55% lower if the blockage were 9%. Estimates of the effects of tunnel blockage on cavity dimensions for cavities formed behind circular disks and of the extent to which cavities of various fineness ratios will be distorted by fixed boundaries are summarized graphically. P. Eisenberg, USA

4078. Engel, F. V. A., and Stainsby, W., Velocity-of-approach factors in unified weir equations, *Proc. Instn. civ. Engrs.* **9,** 165–179, Feb. 1958.

Diversities occur in flow equations as a result of various factors being allocated, somewhat at random, to one or other of their integrating terms. A common procedure has been to combine the head with the velocity of approach. Other authorities combine this term with the coefficient of discharge, which latter can also take into account the geometry of the weir design and fluid properties such as viscosity and surface tension.

It is suggested that the consideration of the velocity-of-approach factor as a separate term, linked neither with the head nor the discharge coefficient, may be useful in interpreting other pertinent factors. An obvious advantage is a simplified evaluation of weir flow measurement. Knowing the head, the discharge can be calculated directly instead of in steps of approximation. Furthermore, the proposed type of basic flow equation, being equally valid for sharp-crested as well as long structures, or standing-wave weirs, permits the discharge coefficient itself to be used as a valuable tool for taking into account the factors which are influenced by weir design and also by characteristics of fluid dynamics.

Paper is restricted to rectangular channels and freely discharging weirs.

The terminology used is explained in so far as it differs from that commonly used. From authors' summary

4079. Kindsvater, C. E., and Carter, R. W., Discharge characteristics of rectangular thin-plate weirs, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (*J. Hydr. Div.*), Pap. 1453, 37 pp., Dec. 1957.

A comprehensive solution is proposed for the discharge characteristics of rectangular thin-plate weirs. The solution is based on a simple equation of discharge and experimentally derived coefficients which account for the influence of the fluid properties and the physical characteristics of the weir and the weir channel. The effects of viscosity and surface tension are related to an increase in the effective head and an increase or decrease in the effective notch width. Thus the combined effects of the fluid properties are accounted for with adjustment coefficients which are applied to measured values of the head and width. Consequently the coefficient of discharge is defined as a function of the width-contraction ratio and the head-weir-height ratio only.

Values of the coefficients required to describe the discharge of water over rectangular thin-plate weirs are determined from original tests covering a wide range of the significant geometric ratios. Additional data needed to confirm the proposed method of analysis are obtained from the published results of experiments by other investigators. The proposed discharge equation is compared with some of the most widely used formulas.

From authors' summary

4080. Jansen, R. B., Flow characteristics on the ogee spillway, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (*J. Hydr. Div.*), Pap. 1452, 12 pp., Dec. 1957.

Although the ogee spillway has been the subject of more research than perhaps any other hydraulic structure, there are still deficiencies in the knowledge of its functioning. There is more to be learned about the process of energy loss on the spillway face and about the effects of submergence of the spillway jet. A general formula is suggested for calculation of the spillway energy loss, and a theoretical derivation is presented defining the limit between the true hydraulic jump and the drowned jump. A criterion for estimating bottom velocities along a level spillway apron is considered. From author's summary

4081. Mostkow, M. A., Theoretical study of bottom-type water intake (in French), *Houille blanche* **12,** 4, 570–580, Sept. 1957.

A bottom-type water intake consists of a horizontal or slightly inclined rack or perforated plate through which water penetrates the intake. Author is mainly concerned in checking the assumption that the specific energy of the flow remains constant above the racks or plate. A formula, based on Boussinesq's equations, yields the water depth above any point of the rack and the minimum rack length required for absorbing a maximum discharge. The theory is compared with test results.

Comments by M. Bouvard point to some differences between Bouvard's approach and the author's treatment.

C. Jaeger, England

4082. Rolle, N. L., Hydraulic investigations of conditions of work of an annular lock (in Russian), *Trudi Leningr. politekhn. in-ta* no. 178, 90–99, 1955; *Ref. Zh. Mekh.* no. 10, 1956.

Paper describes an experimental arrangement of investigating an annular lock. Conditions of working of the annular lock during free discharge and with an extinction chamber dependent on the change in the water level in the lower level are outlined.

The results of the tests are given in the form of three tables and graphs for coefficients of output and resistance of the lock in relation to the degree of opening of the lock and the relationship of the diameter of the pipe and the head of the lower level over the center of the discharge section to the full pressure.

B. K. Konopkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4083. Laursen, E. M., The total sediment load of streams, *Proc. Amer. Soc. civ. Engrs.* **84,** HY 1 (*J. Hydr. Div.*), Pap. 1530, 37 pp., Feb. 1958.

Relationships are proposed which give both the quantity and quality of the total, suspended, and bed loads as functions of the stream and sediment characteristics. In the process of empirically defining the relationships, an encouraging correlation of laboratory and field data (including some original experiments) was obtained. From author's summary

4084. Paulus, J. L. H., and Miller, J. F., Flood frequencies derived from rainfall data, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (*J. Hydr. Div.*), Pap. 1451, 19 pp., Dec. 1957.

The feasibility of using rainfall data to obtain flood frequencies has been demonstrated before. Most investigations, however, utilized rainfall data and rainfall-runoff relations specific to the basins for which the flood-frequency data were desired. The present study, involving 36 basins, shows that the rainfall data need not be from the problem basin and that the data from one precipitation network can be used to synthesize streamflow data for a number of basins. Similarly, rainfall-runoff relations already derived for other basins may be easily modified to apply to the problem basin. The transposition of rainfall data and rainfall-runoff relations not only make it possible to extend the streamflow record of basins not having rainfall data, but greatly reduces the cost of synthesizing streamflow data. From authors' summary

4085. Savitsky, D., Prowse, R. E., and Lueders, D. H., High-speed hydrodynamic characteristics of a flat plate and 20° dead-rise surface in unsymmetrical planing conditions, *NACA TN* 4187, 31 pp. + 4 tables + 28 figs., June 1958.

The results of an investigation made to obtain the wetted areas, the three components of planing forces, and the three components of moments acting on a 0° and a 20° dead-rise surface in high-speed, unsymmetrical planing conditions are presented. Hydrodynamic data were obtained for trim angles between 6° and 30°, roll angles between −15° and 15°, yaw angles between 0° and 20°, mean wetted-length—beam ratios up to 7.7, load coefficients up to 49.0, and speed coefficients up to 18.0.

From authors' summary

4086. McBride, E. E., and Fisher, L. J., An experimental investigation of wake effects on hydro-skids, *NACA TN* 4251, 8 pp. + 1 table + 10 figs., May 1958.

Two combinations of hydro-skis were tested: two hydro-skis in tandem and three hydro-skis arranged with a single front hydro-ski. The results show that the rear hydro-ski in a tandem arrangement could have large increases in lift coefficient and small improvements in lift-drag ratio compared with a hydro-ski in undisturbed water over a limited speed range. The two rear hydro-skis in a three-hydro-ski arrangement would tend to have losses in efficiency compared with hydro-skis in undisturbed water, but the losses could apparently be prevented by carefully selecting the spacing. From authors' summary

Incompressible Flow: Laminar; Viscous

(See also Revs. 4066, 4150, 4156, 4176, 4177, 4186, 4201, 4287, 4288, 4289, 4293, 4294, 4297, 4305)

Book—4087. Barna, P. S., Fluid mechanics for engineers, London, Butterworths Scientific Publications, 1957, x + 377 pp.

Book is intended to serve as a text for undergraduate courses on fluid mechanics, both for civil engineers and for mechanical engineers. Reviewer thinks that subject has been well covered, and that organization of text is commendable. Each chapter is followed by numerous examples and problems and by a short bibliography, mostly of well-known texts. The following chapters are organized in three parts: Part 1, 1. Fluid statics; 2. Perfect fluids in motion; 3. Viscous fluids in motion; 4. Flow in closed conduits; 5. Flow in open channels; 6. Fluid metering; 7. Dimensional analysis of fluid flow phenomena; 8. Boundary-layer theory; 9. Elements of wing theory. Part 2, 10. Fundamentals of the flow of compressible fluids. Part 3, 11. Centrifugal pumps and fans; 12. Axial flow pumps and fans; 13. Hydraulic turbines.

Reviewer would like to make the following comments on certain topics of the text. Reference is made on page 19 to Bernoulli's original equation. In his "Hydrodynamica," Bernoulli did not use the familiar three-term equation, but simply stated that the sum of the piezometric head and the kinetic energy is constant along the flow, thus including in a single term the potential and the pressure energies. On page 26, author derives the "momentum equation," as applied to solids and to liquids. Author makes no mention to transient phenomena. Reviewer thinks that, without losing the elementary character of the book, author could have used the vectorial notation: $P + G + L + M_1 - M_2 = 0$, in which P is resultant of surface forces acting on the fluid, G the weight, L the local momentum, M_1 the momentum of fluid entering the considered volume and M_2 the momentum of fluid leaving the considered volume. This formula, used in Italian texts [see De Marchi, "Idraulica," Hoepli, Milan, 1939], would be convenient to use, for instance, in Example 2.7 in which author takes into consideration only the resultant of momenta, thus giving an incomplete solution. The forces acting upon the flanges of the bend are given not only by the momentum "forces," but also by the pressures exerted on the fluid at those sections, and by the weight of fluid between flanges. On page 81, when discussing specific energy for open channels, it could be convenient to emphasize that depth represents piezometric head with respect to bottom only if slope is mild. For chutes, for example, the piezometric head is given by $d \cdot \cos \alpha$. In chap. 6, a reference should be made to critical flow meters, in reviewer's opinion. Chapter on boundary layer is very complete, within the frame of the book. Caption of Fig. 9.8 (c) mentions "viscous." Reviewer thinks that the word should be changed to "parallel." Reviewer thinks that a chapter on transient phenomena (water hammer, surges, waves, etc.) could be added to the book without losing its present character. On page 238, a definition is missing of the internal energy and of J. Letter "E" was used for internal energy, and was previously used for total energy in incompressible flow (see p. 20). Reviewer thinks that author should emphasize the similarity between supersonic, critical and subsonic flows, with supercritical, critical and subcritical flows in open channels. Same remark would apply to shock waves and hydraulic jumps. This book presents the rare opportunity of dealing in the same text with both fields. A. Balloffet, USA

4088. Mohr, W. D., Saxton, R. L., and Jepson, C. H., Mixing in laminar-flow systems, *Indust. Engng. Chem.* **49,** 11, 1855–1856, Nov. 1957.

Paper deals essentially with the rate of change in the surface area of a liquid cube suspended in another liquid, when the mixture is subjected to a uniform shear stress. The calculation involves an application of Newton's formula for fluid shear and of the rudiments of Euclidean geometry. C.-S. Yih, USA

4089. Herzig, H. Z., and Hansen, A. G., Experimental and analytical investigation of secondary flows in ducts, *J. aero. Sci.* **24,** 3, 217–231, Mar. 1957.

Smoke flow visualization was used to examine the secondary flows in rectangular cross-section ducts of 90° deflection with circular arc constant area and converging area. The flows in two other ducts, one with acceleration followed by a bend and the other with a bend followed by acceleration, were also examined.

Theoretical solutions for three-dimensional boundary-layer flows, assuming laminar main streamline translates, are given for uniform mainstream velocity in the x direction and a translate mainstream velocity in the crossflow direction expressible as a polynomial in x. Tables of special functions of the Blasius similarity parameter required for computing such boundary-layer crossflows are presented. Several interesting examples of cross-channel flows are computed for thick and thin boundary layers and compared satisfactorily with the experiments.

Reviewer believes that this represents a valuable contribution to the theory of three-dimensional boundary-layer flow.
W. R. Hawthorne, England

4090. Woods, L. C., On the deflexion of jets by aerofoils, *Quart. J. Mech. appl. Math.* **11,** Part I, 24–38, Feb. 1958.

An exact solution is given of the flow past a two-dimensional airfoil at incidence in a free jet. It has application to wind-tunnel and water-tunnel interference problems and to free jet-deflection problems.

A conformal transformation method is used in which the flow region is transformed into a rectangular contour by the use of Jacobean elliptic functions. Of particular interest is the angle of deflection for a given airfoil incidence and chord-to-jet width mounted centrally in the jet. The theory is, however, quite general and deals with the case of the off-center airfoil.

The results are compared with those of Havelock [*Proc. roy. Soc.* (*A*) **166,** 178–196, 1938] who, considering the same problem, applied the jet boundary condition on lines parallel to the y-axis instead of on the free surface itself. It is shown however that Havelock's expression for $dC_L/d\alpha$ is similar to that obtained by the author if Havelock's incidence is measured relative to the average of the upstream and downstream jet directions and not from the upstream direction as implied in that paper.

Reviewer draws attention to the application of this theory to the problem of a jet flowing past a deflected surface (Coanda effect) when boundary-layer effects are neglected. The surface in that case would replace the stagnation streamlines and upper surface of the airfoil. G. M. Lilley, England

4091. Rouse, H., Diffusion in the lee of a two-dimensional jet (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 307–315.

Paper discusses some experimental measurements of flow pattern and pressure distribution in the lee of a vertical jet from a wall parallel to a uniform stream. Comparison of this type of flow to that over a normal wall is given. S. I. Pai, USA

4092. Maskell, E. C., and Gates, S. B., Preliminary analysis for a jet flap system in two-dimensional inviscid flow, *Aero. Res. Counc. Lond. curr. Pap.* no. 359, 21 pp. + 6 figs., 1957.

A number of relations pertaining to the flow of thin jets from airfoils are derived by simple means. The flow is considered to be two-dimensional and inviscid; compressibility is taken into account in the jet only. Both source and ducted body type of jet flaps are treated. L. J. F. Broer, Holland

4093. Goleevskii, A. A., Questions on the mechanics of jet motion of liquids and gases, [Voprosy mekhaniki struinogo dvizheniya zhidkostei i gazov], Leningrad, Mashinostroitenoi Promyshlennosti, 1957, 88 pp. (Paperbound)

Approximative formulas for the calculation of free jets are given without entering into turbulent motion theory. A linear decrease of the jet core is assumed, which, however, does not agree very well with experimental observations. The formulas are also extended to cover the conditions of flames. The second part refers to jets emerging in a channel with bordering walls and also to multiple jets influencing one another. Wake flows in channels are also considered. A theory of jet pumps is established in the concluding part and the mixing velocity is calculated for the subsonic and supersonic case.

In a short appendix author tries to explain the formation of ripples by a jet flow separated from the crests. The exposition of the problems is somewhat elementary compared with existing books on jet motion. W. Wuest, Germany

4094. Janssen, E., Flow past a flat plate at low Reynolds numbers, *J. Fluid Mech.* **3,** 4, 329–343, Jan. 1958.

The flow past a flat plate at Reynolds numbers in the range 0.1 to 10.0 is investigated by an analog method. The solution gives the stream function and the vorticity in the flow field surrounding the plate. From these are obtained the local coefficient of friction, the pressure distribution along the plate, and the total drag coefficient. The drag coefficient approaches the analytical values of Haaser (1950), and of Tomotika and Aoi (1953) as the Reynolds number decreases toward 0.1. The drag coefficient approaches the Blasius solution as the Reynolds number increases. At Reynolds number 10.0 the drag coefficient is still above the Blasius value, but is below the value obtained experimentally by Janour (1951). The difference from the experimental result is attributed for the most part to truncation error.

From author's summary by T. Y. Toong, USA

4095. Schlichting, H., Cascade flow problems, *AGARD Rep.* 93, 14 pp., Feb. 1957.

Report gives a brief insight into some theoretical and experimental research work on aerodynamic cascade problems done in recent years at the Institute of Fluid Mechanics of the Engineering University of Braunschweig, Germany. Some of this work has already been published in more detailed papers.

An extensive program of theoretical calculations of cascade characteristics (pressure distribution, deflection, flow-loss) in two-dimensional incompressible cascade flow has been carried out applying boundary-layer theory [see: L. Speidel, N. Scholz, *VDI-Forschungsheft* 464, 1957]. There is good agreement between theory and experiment. Using theoretical results of two-dimensional cascade flow and additional computations for the secondary flow, the total head and efficiency versus mass flow has been calculated purely theoretically for an axial compressor stage [see AMR **10** (1957), Rev. 2248]. Furthermore some results of pressure distribution measurements on cascades at high subsonic Mach numbers are presented.

In the subcritical range the results agree fairly well with theoretical calculations using the Prandtl-Glauert rule for compressibility correction [see H. Schlichting, E. G. Feindt, *Forsch. Geb. Ing. Wes.* **24,** 19–28, 1958]. Measurements have been carried out in a new variable-density high-speed cascade wind tunnel, which allows independent variation of Reynolds and Mach number. Later work in this field will include measurements of loss coefficient. N. Scholz, Germany

4096. Jaumotte, A. L., and Devienne, P., Effect of Reynolds number on the losses in a cascade of airfoils (in French), 9th Congrès intern. Mécan. appl. Univ. Bruxelles, 1957; **2,** 233–244.

A number of definitions of the loss coefficient for a cascade of airfoils are given, and their relative ease of measurement and accuracy are considered. The coefficient adopted is the ratio of the mean pressure measured across the wake to the dynamic head at the exit, measured away from the wake. The variation of this coefficient with the Reynolds number based on the semiperimeter of the airfoils is measured for three cascades, one accelerating, one decelerating, and one turning the flow. Results are compared with the friction coefficient for flat-plate flow, and transition is shown to occur over approximately the same range of Reynolds number. R. N. Cox, England

4097. Railly, J. W., Lift distribution and secondary flow for a cascade in nonuniform flow (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 320–330.

The inviscid incompressible flow around a cascade in a nonuniform flow is treated theoretically. By assuming that the perturbation in the nonuniform flow due to the cascade is small a linear equation in the Trefftz plane is obtained which is subject to discontinuities at the image of each lifting surface.

An analytical solution is obtained by separation of variables for a linear velocity distribution. For a parabolic velocity distribution the secondary velocity is computed by relaxation and used to compute the induced drag and deflection angle.

W. Squire, USA

4098. Armstrong, W. D., The secondary flow in a cascade of turbine blades, *Aero. Res. Counc. Lond. Rep. Mem.* 2979, 14 pp., 1957.

An investigation of a cascade of "impulse" turbine blades was made in a 150 hp pressure wind tunnel. Nine 6-in. chord blades were used with a blade spacing of 6 in., the aspect ratio being 3. The blade shape was one constructed entirely of straight lines and circular arcs. To provide a slight pressure drop through the blading, thereby obviating extensive secondary stalling, the blades were set at a stagger angle of +10 deg and air inlet angle of 35 deg. The design outlet angle was 37 deg. Two groups of tests were made, one used an artificially thickened wall boundary layer to give a low upstream vorticity and in the second the two natural boundary layers formed on the tunnel walls perpendicular to the blade length constituted the nonuniformity. The natural boundary layers have the usual turbulent form with an overall thickness of about 1 in., leaving a central region of uniform flow 16 in. wide. Measurements were made one chord upstream of the blades and in planes between the trailing edge and a position 1½ chords downstream. In each traverse plane the total head and air angles in two perpendicular planes were determined. The experimental results are presented in the form of maps.

It has been shown that when the secondary vorticity is sufficiently small the perturbation theory may be used to predict accurately the induced velocities downstream of the blades which are due to this disturbed vorticity. As the upstream vorticity or

the blade deflection is increased, then the perturbation theory is no longer applicable and the transport of the Bernoulli surfaces within the blade passages must be considered. In a particular case a crude approximate method has been given for the calculation of the distributed circulation but this itself does not enable the induced velocities to be computed. L. Goland, USA

4099. Polyakhov, N. N., Lattice theory of plates according to N. E. Zhukovskii and its generalization to include the case of an arbitrary profile (in Russian), *Vest. Leningr. in-ta* no. 1, 125–144, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1859.

A method of calculation is described for the established potential flow of an incompressible liquid through a flat lattice section. The method is based on the presentation of a function, reflecting the outward form of the lattice of some canonical ovals from the plane ξ_0 (or circles from the plane $\xi_1 = \operatorname{cth}(\pi\xi_0/t)$ [note by the abstractor]) on the plane of flow z in the sum $z = z_1 + \Delta z$, where z_1 relates to the equivalent lattice of the plates, while Δz is a regular function, the coefficients of whose resolution are found by the usual successive approximations in the region $\xi_1 = e^{i\theta}$. For the first approximation a suitable theoretical lattice is recommended. The method described differs from those known previously because of the use of the theoretical lattice instead of the plate lattice and is not effective in the case of dense lattices of strongly curved shapes. No calculations are given. G. Yu. Stepanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4100. Kawasaki, T., On the direction of outlet flow of a cascade of airfoils, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 323–326.

Theoretical formulation is developed for estimation of trailing edge meanline flow-deflection angle δ for cascades. In coordinate system with origin at trailing edge, perturbation velocities are based on vortex-source distribution on x-axis tangent to camber-line, with boundary conditions specified by thickness-camber distributions. Various trailing edge configurational effects are interpreted, with δ defined linearly in terms of these. Author compares theory with test results on both compressor and turbine cascades for a wide range of staggers and solidities of 1.0, 0.8, 0.52. Good agreement is shown in compressor case. Theory, seemingly uniformly, appreciably underestimates turbine test results by one to two degrees. P. R. Hardesty, USA

4101. Wada, I., Aerodynamic research on accelerating cascade (III). Cascade test of the nozzle blades, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 333–336.

Low-speed ($W_1 = 40$ mps; $Re = 2.7 \times 10^5$) cascade-wind-tunnel tests on turbine-lattice configurations. Some test dependencies of outflow direction and loss coefficient are given, for several high cambers, on Re up to $Re = 3.0 \times 10^5$. Test results on loss coefficient for solidities 0.52, 0.8, 1.0 are plotted against total turning angle from 0.5 to 1.25 radians. Solidity 1.0 shows low loss up to crossing of solidity 0.8 at 0.67 radians, then solidity 0.52 at 1.1 radians. P. R. Hardesty, USA

4102. Viswanadha Sarma, L. V. K., Slow motion of a paraboloid of revolution in a rotating fluid, *J. Fluid Mech.* **3,** 4, 404–410, Jan. 1958.

Author studies the slow uniform motion, after an impulsive start, of a paraboloid of revolution along the axis of a rotating fluid. After linearizing the equations of the motion relative to the undisturbed rotation he uses the technique of the Laplace transformation to obtain a neat form for the flow. He finds that ultimately the motion consists of the initial rotation and a uniform drift along the axis with the same velocity as the paraboloid. The solution is used to explain the mechanism by which the fluid is not subjected to any substantial radial displacement. K. Stewartson, England

4103. Hasimoto, H., The unsteady axial motion of an infinitely long cylinder in a viscous fluid (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 135–144.

Motion of an incompressible viscous fluid generated by cylinder of arbitrary cross section moving with periodic velocity in direction of its generator is considered. Navier-Stokes equations, equation of continuity, and condition that velocity on surface is periodic in time and approaches zero as distance from axis becomes very large are satisfied. Results are obtained for magnitude of frictional drag per unit length and its phase lead time when Reynolds number based on frequency is small and also when frequency divided by kinematic viscosity is large. Latter results are corrected for presence of a comer. Because of convexity of its surface, for same perimeter the circular cylinder has largest value of local friction.

Circular cylinder with uniform suction or injection and in unsteady axial motion is also treated. Convexity of surface is found to be equivalent to suction. One application is Rayleigh's problem for a circular cylinder with suction or injection, for which expression for frictional drag per unit area is given. N. Tetervin, USA

4104. Kestin, J., and Persen, L. N., Slow oscillations of bodies of revolution in a viscous fluid (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 326–338.

A general method for solving problems of slow torsional oscillations of bodies of revolution possessing analytic surfaces is outlined. The corresponding mathematical problem is solved by the use of the Laplace transform. The case of an infinite circular disk oscillating between two fixed plates under the influence of an elastic force or couple is discussed in detail. The motion of the disk can be interpreted as a damped harmonic motion superimposed on a drifting zero position.

The same method is then applied to spheres and infinite cylinders oscillating either in free space or in concentric fixed spheres or cylinders. Also considered are cylinders and spheres filled with a fluid and piles of equally thick infinite disks. In all these cases the motion exhibits the same features as in the case of an infinite disk. E. Leimanis, Canada

4105. Dittrich, R. T., Discharge coefficients for combustor-liner air-entry holes. II. Flush rectangular holes, step louver, and scoops, *NACA TN* 3924, 14 pp. + 1 table + 22 figs., Apr. 1958.

Experimental discharge coefficients for various types of combustor-liner air-entry holes are presented as a function of a dimensionless flow parameter. In general, scoops and step louvers have higher discharge coefficients and wider flow ranges than flush holes. The effects of size or shape of a given type of hole are small. The proximity of multiple flush holes or the wall inclination of a convergent duct has a negligible effect on discharge coefficient. From author's summary

Compressible Flow, Gas Dynamics

(See also Revs. 3873, 3968, 4087, 4146, 4151, 4190, 4191, 4210, 4231, 4257, 4258, 4264)

4106. Stretensky, L. N., Two problems in the theory of gas jets (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 449–455.

The two problems considered are

(1) The focusing of a jet of compressible fluid originally moving with subsonic velocity between a pair of symmetrically disposed finite plates inclined to the mean direction of the jet.

(2) The bifurcation of a similar jet by a finite plate symmetrically placed across the jet.

Each problem is solved in the hodograph plane by Chaplygin's method and formal expression for the velocity and width of the jets a long way downstream of the plates are obtained.

No numerical results are given.

K. Stewartson, England

4107. Jacob, C., The effect of solid boundaries on subsonic jets (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 464–475.

Paper is concerned with the application of the Rayleigh-Jantzen theory to the flow of a gas jet past fixed obstacles. It is based, following Imai, on the use of the complex variable, and terms of order M^4 are neglected where M is the Mach number of the undisturbed jet. The conditions which the complex potential must satisfy are obtained, but no explicit results are given and there is no discussion. K. Stewartson, England

4108. Seddon, J., The flow through short straight pipes in a compressible viscous stream, *Aero. Res. Counc. Lond. curr. Pap.* 355, 17 pp. + 16 figs., 1957.

Flow of a compressible viscous fluid through short contracting and expanding pipes immersed in an air stream is investigaged, and the different flow regimes are delineated in terms of boundary-layer growth and inlet and exit choking. The effects of yaw are briefly discussed and applications to modelling of jet-engine nacelles are indicated. A. F. Pillow, Australia

4109. Tabachnikov, L. Ya., Determination of the disturbing function created by the exhaust gases of an internal combustion two-stroke engine (in Russian), *Trudi Tallinsk. politekhn. in-ta* (*A*) no. 47, 3–16, 1953; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1830.

The effects are examined which occur in the conduits of exhaust gases of two-stroke engines and some concepts are advanced which permit not only the determination of the disturbance characteristics, set up by the exhaust gases, but also the calculated values of the harmonic components of this disturbance. The author makes the deduction that the known values of the harmonic coefficients of disturbance allow the carrying out of the investigation of the compelled oscillations of gases in the exhaust system of a two-stroke engine. The results of this investigation give the possibility of carrying out an accurate evaluation of the "blow through" (scavenger) of the engine, of correctly designing the exhaust system and improving the calculations for a gas turbine, working on the pulsating flow of the exhaust gases of the engine.

V. I. Kersanov

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Translation, courtesy Ministry of Supply, England

4110. Ovsiannikov, L. V., A new solution of the hydrodynamic equations (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **111**, 1, 47–49, 1956 (translated from Russian by M. D. Friedman, 67 Reservoir St., Needham, Mass., 0–107, 5 pp.).

The author gives an exact solution of the equation of adiabatic motion of a compressible fluid; i.e., of

$$\frac{d}{dt}\,\mathbf{u} + \frac{1}{\rho}\,\nabla p = 0$$

$$\frac{d}{dt}\log\rho + \operatorname{div}\mathbf{u} = 0$$

$$\frac{d}{dt}\log p + \gamma \operatorname{div}\mathbf{u} = 0$$

where the variables have their usual significance and d/dt denotes along a trajectory $d\mathbf{x}/dt = \mathbf{u}$. The particular solution is $\mathbf{u} = \frac{dM}{dt}M^{-1}\mathbf{x}$, $\rho = |M|^{-1}F(M^{-1}\mathbf{x})$, $p = |M|^{-\gamma}G(M^{-1}\mathbf{x})$, where L is a constant square third-order matrix and $F(\xi)$ and $G(\xi)$ functions satisfying

$$\nabla G = F(L\xi)$$

and M is a nonsingular square matrix satisfying

$$M^{*}\frac{d^2M}{dt^2} + |M|^{1-\gamma}L = 0;$$

here M^{*} is the transpose and $|M|$ the absolute value of the determinant of M. The possible forms of L, F, and G are discussed, as well as first integrals for M. No physically interpretable solution is given. M. P. O'Brien, USA

4111. Hamamoto, I., Design of cascade in compressible fluid and application, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 337–340.

Theoretical formulation is outlined for solution of cascade problem for subsonic flow. Analysis appears to depend in part on assumption of gas with $\gamma = -1$. Potential and stream functions are developed in terms of polar coordinates of a reduced velocity vector. Velocity vector finally is represented at surface and in flow by integral expressions apparently deriving from Poisson integral. Complete set of mapping functions appears in appendix. Application to "indirect" problem depends on stipulation of inflow vector, deflection diagram, and variation of velocity magnitude. Direction of surface velocity and shape of surface result from procedure. Solution of "direct" problem is sketched, based on an iterative procedure starting with incompressible solution.

P. R. Hardesty, USA

4112. Krasilchtchikova, E. A., Unsteady motions of thin airfoil in compressible medium (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3**, 68–74.

The velocity potential in any point of a two-dimensional airfoil is calculated when the forward speed of the airfoil varies arbitrarily, both subsonic and supersonic values being admitted. The velocity potential satisfies the wave equation $\varphi_{xx} + \varphi_{zz} = (1/c^2)\varphi_{tt}$, where the system of coordinates is fixed to the fluid. The solution uses the characteristics of this equation in the x, t-phase. Another way of illustrating the method of solution is to say that it uses the analogy between two-dimensional unsteady flow and three-dimensional steady flow. The same method has been used by Lomax, Heaslet, Fuller and Sluder [AMR **7** (1954), Rev. 241]. For subsonic speeds, an Evvard problem must be solved, while for supersonic speeds the solution is immediately given by an integral. A. I. van de Vooren, Holland

4113. Taylor, R. A., and McDevitt, J. B., Pressure distributions at transonic speeds for parabolic-arc bodies of revolution having fineness ratios of 10, 12, and 14, *NACA TN* 4234, 11 pp. + 18 figs., Mar. 1958.

The measured static-pressure distributions at the model surface and in the surrounding flow field are presented for the bodies at zero angle of attack. The Mach number range extended from 0.80 to 1.20 and the Reynolds number range was 23.4 to 10^6 to 28.6 × 10^6 (based on the theoretical length of the model).

From authors' summary

4114. Lindsey, W. F., and Landrum, Emma Jean, Compilation of information on the transonic attachment of flows at the leading edges of airfoils, *NACA TN* 4204, 18 pp. + 2 tables + 35 figs., Feb. 1958.

Schlieren photographs have been compiled of the two-dimensional flow at transonic speeds past 37 airfoils. These airfoils have variously shaped profiles, and some are related in thickness and camber. The data for these airfoils were analyzed to provide basic information on the flow changes involved and to determine factors affecting transonic-flow attachment, which is a transition from separated to unseparated flow at the leading edges of two-dimensional airfoils at fixed angles as the subsonic Mach number is increased. From authors' summary

4115. Clouston, J. G., Gaydon, A. G., and Glass, I. I., Temperature measurements of shock waves by the spectrum-line reversal method, *Nature* **181,** 4619, 1325–1326, May, 1958.

4116. Josephson, V., Production of high-velocity shocks, *J. appl. Phys.* **29,** 1, 30–32, Jan. 1958.

High-velocity axial shocks have been produced in linear gas discharge systems by so shaping the discharge tube (and discharge) that a maximum amount of energy is coupled into the ionized gas before the shock is formed. Two methods of coupling energy into the gas are discussed along with their relative merits and shock velocities achieved by each method.

From author's summary

4117. Whitham, G. B., A note on the stand-off distance of the shock in high-speed flow past a circular cylinder, *Comm. pure appl. Math.* **10,** 4, 531–535, Nov. 1957.

Author follows Lighthill's approach [*J. Fluid Mech.* **2,** 1–32, 1957] for predicting the stand-off distance in the case of high-speed flow past a sphere. Assuming a cylindrical shock, he notes that just behind the shock the vorticity ω and the stream function ψ are both proportional to the distance from the plane of symmetry. Now in two-dimensional incompressible flow ω is constant along a streamline, thus $\omega = (const)\,\psi$ everywhere. Substituting this into the equation for ψ, a linear equation for ψ is obtained and is solved in terms of Bessel functions. Results agree with those obtained by series methods [AMR **10** (1957), Revs. 3696, 3704]. F. A. Goldsworthy, England

4118. Love, E. S., and Long, R. H., A rapid method for predicting attached-shock shape, *NACA TN* 4167, 34 pp., Oct. 1957.

Analysis is for attached shocks on smoothly contoured axisymmetric and two-dimensional nose shapes, with Mach numbers from 1.5 to 5.0. Method is to fit a circular arc to nose and use shock shapes calculated in paper for circular arcs of various thicknesses and at various Mach numbers by method of characteristics. Accuracy is comparable to method of characteristics.

A. E. Bryson, Jr., USA

4119. Hurrell, H. G., Analysis of shock motion in ducts during disturbances in downstream pressure, *NACA TN* 4090, 10 pp. + 1 fig., Sept. 1957.

Analysis presented is linearized and assumes rate of variation of duct area in flow direction is not very large. Results are presented in terms of Laplace transform for cases of (1) varying area ducts and (2) constant area duct. Results are shown to be in agreement with known qualitative behavior, and a graph is provided to make computations practical. Reviewer believes analysis should therefore be of utility in engine design despite limitation to small disturbances, particularly since a more complete analysis is not available. S. J. Kline, USA

4120. Guienne, P., and Bouniol, F., Application of interferometry to the study of the flow of a viscous fluid downstream of a detached shock wave (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 87–100.

The laws of inviscid flow are often applied to determine the rotational flow downstream of a shock wave. Authors investigate the validity of this assumption by considering the effects of viscosity and heat conduction, assuming that the changes in entropy and enthalpy are small. The dissipation function and the mechanical and thermal energy changes are expressed as a function of the specific mass and its derivatives, these being obtained by interferometry.

The theory is applied to the flow in front of leading edge of a round-nosed profile at $M = 1.96$. Effects of viscosity and conduction are found to be negligible. The increase in wave drag due to these effects is very small and is independent of the scale of the model. A. W. Babister, Scotland

4121. Lype, E. F., The use of shock-wave observations for the determination of the equation of state (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 146–155.

Paper is a theoretical discussion of the differential equations which enable one to derive, by using the so-called Hugoniot function, thermodynamic properties of substances from the observed characteristics of shock-wave propagation.

D. ter Haar, England

4122. James, C. S., Observations of turbulent-burst geometry and growth in supersonic flow, *NACA TN* 4235, 31 pp. + 1 table + 20 figs., Apr. 1958.

Some aspects of the mechanics of boundary-layer transition have been deduced from a study of shadowgraphs of free-flight models at free-stream Mach numbers between 2.7 and 10. That part of the transition process between the first appearance of turbulence vortices and the end result of continuously turbulent flow is found to occur in supersonic flow in a manner closely similar to its observed occurrence in subsonic flow. Minute spots, or bursts, of turbulence form near the leading edge and are swept aft. The rates at which these bursts form and grow are found to vary gradually with Mach number, unit Reynolds number, and surface roughness. From author's summary

4123. Charwat, A. F., and Yakura, J. K., An investigation of two-dimensional supersonic base pressures, *J. aero. Sci.* **25,** 2, 122–128, Feb. 1958.

An investigation of the base pressure behind wedges at Mach numbers 2 and 3 in the laminar and the transitional regime is reported. Temperature and velocity traverses through the mixing zone are shown and exploratory investigations of the wake vortex by use of hot wires and flow-visualization techniques are described. It is found that the laminar two-dimensional base pressure agrees well with Chapman's theoretical predictions. The shear layer exhibits gross velocity distribution characteristic of the free jet mixing zone, but also shows disturbances that originate in the expansion-turning of the oncoming boundary layer. An interesting trailing vortex is observed, which is explained in terms of nonuniform mixing rate in the wake.

From authors' summary

4124. Buford, W. E., The effects of afterbody length and Mach number on the normal force and center of pressure of conical and ogival nose bodies, *J. aero. Sci.* **25,** 2, 103–108, Feb. 1958.

Measurements have been made of the normal force and center of pressure of bodies of revolution at supersonic Mach numbers from 1.36 to 4.0. Conical and ogival nose bodies, with cylindrical afterbody length varying systematically from 0 to 11 calibers, were studied. The purpose of this study was to describe in a systematic manner the variation of the body aerodynamic characteristics with afterbody length and Mach number. Author's data are in reasonable agreement with the theoretical values predicted by Van Dyke's improved treatment of the first-order axial and crossflows. From author's summary

4125. Meyer, R. E., The structure of supersonic flow, Brown Univ., Div. appl. Math., AFOSR TN-58-52 (AD 148 094), 15 pp., Jan. 1958.

Some of the known facts regarding the structure in the large of steady, two-dimensional shock-free supersonic flow are presented together with new results and points of view. In particular, invariant properties of wave fronts, branch lines, and limit lines are discussed. H. Mirels, USA

4126. Lampert, S., Drag due to lift for delta wings at supersonic speeds, *J. aero. Sci.* **24,** 12, 919–920 (Readers' Forum), Dec. 1957.

The linear theory is compared with some of the experimental results obtained in tests conducted on delta wings at the Jet Propulsion Laboratory. From author's summary

4127. Trilling, L., and Clark, J. W., The aerodynamic force coefficients of yawed slender configurations at high Mach numbers, *J. aero. Sci.* **24,** 12, 913–914 (Readers' Forum), Dec. 1957.

This note presents a simple method of evaluating the aerodynamic force coefficients on a highly yawed slender body at high Mach numbers. The basic idea is that if the Mach number is of order 5 to 7 and the angle of yaw is of order 8° to 12°, the effective crossflow Mach number is of order 0.75 to 1.5. The splitting of the total flow field into an axial flow and a crossflow is still legitimate, but the analysis of the crossflow is difficult since it is the plane transonic flow past a blunt body with turbulent separation on the leeward side.

Since no simple technique now available permits the calculation of such a flow, the present investigation consisted of measuring the pressure distribution on the windward side of appropriate blunt bodies in the transonic wind tunnel to provide the data needed for the evaluation of the side force coefficient in the hypersonic regime. From authors' summary

4128. van Driest, E. R., and Boison, J. C., Experiments on boundary-layer transition at supersonic speeds, *J. aero. Sci.* **24,** 12, 885–899, Dec. 1957.

Tests were conducted in the 12-in. continuous supersonic wind tunnel of the Jet Propulsion Laboratory, California Institute of Technology, to determine the effects of surface cooling on boundary-layer transition at supersonic speeds. The effects of cooling were investigated at test section Mach numbers of 1.97, 2.81, and 3.84 with an internally cooled 20-in. 10° (apex angle) smooth cone in the presence of three levels of supply-stream turbulence (0.4, 2, and 9%) and several single-element roughnesses at fixed axial location. Transition data were obtained optically by means of a magnified-schlieren system. The results, for the range of Mach numbers investigated, indicate that (1) transition on a smooth cone can definitely be delayed by surface cooling, (2) transition promoted by either supply-stream turbulence or surface roughness can also be delayed by surface cooling depending upon degree of turbulence or relative roughness, respectively, and (3) the adverse effects of increased turbulence and roughness decrease with increasing Mach number.

From authors' summary

4129. Napolitano, L. G., and Ferri, A., The axisymmetric supersonic flow near the nose of a pointed body of revolution, *J. aero. Sci.* **24,** 12, 900–904, Dec. 1957.

An approximative method of solution for the supersonic flow about axisymmetric bodies is given. It is based on the method of linearized characteristics given in a preceding publication [see AMR **5** (1952), Rev. 1137]. In the present application the basic flow has been taken to be that corresponding to the flow about a cone coincident with the tangent to the body at its apex. The body shape is represented in terms of a power series in the axial coordinate and the entire flow field is determined in terms of a similar series. An upper limit of the validity of the assumption that the perturbation derivatives remain finite and small throughout the flow field can be obtained. As a numerical example the flow about the nose of the RM^{-10} body has been analyzed for several flight Mach numbers and the results shown to be in good agreement with other methods of analysis. An extension of the calculation method to more general fields without axial symmetry is being prepared by the authors. W. Wuest, Germany

4130. Ryan, B. M., Drag due to lift at supersonic speeds for a swept wing composed of two oppositely-yawed elliptical planforms, Douglas Aircr. Co. Rep. no. SM-22987, 34 pp., Nov. 1957.

Reductions in drag are obtained when a uniformly loaded elliptical wing is yawed with respect to the windstream. A swept wing can be approximated by two oppositely yawed elliptical wings. Purpose of the paper is to determine the drag of the swept wing consisting of two coplanar overlapping elliptical planforms and compare it with the drag of the two noninterfering coplanar wings.

Method used is based on works by R. T. Jones, Hayes and Graham. It is shown that the interference wave drag is always positive and that the interference vortex drag is negative for most cases when the "overlap" of the wings is small. Conclusion is that the net drag in most cases of interfering wings is smaller than for the noninterfering wing when the overlap is small. The loading is however not optimum, so that a further reduction in the drag could be effected by the addition of favorably interfering lift distributions. T. Gullstrand, Sweden

4131. Allen, H. J., and Eggers, A. J., Jr., A study of the motion and aerodynamic heating of missiles entering the earth's atmosphere at high supersonic speeds, *NACA RM* A53D28, 62 pp., Aug. 1953, declassified Apr. 1957.

An analysis for the trajectory and heat transfer of a body entering the earth's atmosphere is presented in a simplified manner. The trajectory analysis assumes: (1) an exponential variation in atmosphere density, (2) a constant drag coefficient, and (3) that gravity may be neglected. The third assumption results in a linear flight path, which is shown to be valid well below the altitude of maximum deceleration, as long as the entry angle is not too shallow, by comparison with calculations that include gravity. Several interesting results of the trajectory analysis are: (1) the maximum deceleration is a function only of entry speed and flight-path angle, (2) the altitude for maximum deceleration depends only on the physical characteristics of the body and the flight-path angle, and (3) the speed at maximum deceleration is 61% of the entry speed.

The aerodynamic heating analysis, though more qualitative than the trajectory analysis, should allow prediction of relative heating rates of hypersonic speeds. Hence changes in the trajectory or in the body characteristics may be evaluated qualitatively but not in an absolute sense. It is concluded that convective heating is minimized for "relatively heavy" bodies, that is, bodies that are not greatly retarded by aerodynamic drag, by minimizing the total shear force acting on the body. This is accomplished by choosing a low-pressure drag shape. On the other hand, convective heating is minimized for "relatively light" bodies by choosing high-pressure drag shapes.

As a general result, it appears that blunt shapes hold considerable promise in minimizing heat transfer to missiles of current interest. A number of examples are presented which illustrate the analysis. E. R. van Driest, USA

4132. Monaghan, R. J., Formulae and approximations for aerodynamic heating rates in high-speed flight, *Aero. Res. Counc. Lond. curr. Pap.* 360, 31 pp. + 19 figs., 1957.

Author aims "to give formulae and methods for use in preliminary calculations (including approximations for "thick" and

"thin" skins) and to show the relative importance of the various parameters rather than to give a broad description of the problems of aerodynamic heating." This he does, up to Mach number 5 using background information available in 1955, when the paper was written. Unyawed flat-plate and cone formulas are used and the longitudinal temperature and pressure gradients are neglected.

M. V. Morkovin, USA

4133. Stepaichuk, V. F., Investigation of the work of straight supersonic nozzles by the method of suspension of the reaction force (in Russian), *Sb. nauch. rabot Belorus. politekhn. in-ta* no. 53, 108–115, 1956; *Ref. Zh. Mekh.* no. 2, 1957; Rev. 1749.

Results are submitted of an experimental investigation on a number of supersonic nozzles with conical expanding sections. The experiments were carried out to determine the velocity coefficient, which may be visualized as the ratio of the actual velocity of the flow on a section of the nozzle to the theoretical velocity in the presence of isoentropic expansion. Since in the experiments the consumption of air through the nozzle was not measured, the experimental dependencies are built up in the form of the coefficient of thrust power arising from the fall of pressure at various values for the angle of opening of the nozzle and the theoretical velocity of outflows. Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4134. Bird, G. A., Some remarks on the foundations of piston theory and supersonic-hypersonic similarity, *J. aero. Sci.* **25,** 2, 138–139 (Readers' Forum), Feb. 1958.

4135. Scala, S. M., Estimating aerodynamic characteristic times in hypersonic flow, *J. aero. Sci.* **25,** 2, 131–132 (Readers' Forum), Feb. 1958.

4136. Steckelmacher, W., The flow of gas at very low pressure, *Brit. J. appl. Phys.* **8,** 12, 494–495 (Notes and News section), Dec. 1957.

4137. Rose, P. H., Physical gas dynamics research at the AVCO Research Laboratory, *AGARD Rep.* 145, 17 pp. + 2 tables + 25 figs., July, 1957.

4138. Yang, H.-T., The effect of molecular vibration on recovery temperature in plane Couette flow, *J. aero. Sci.*, **24,** 12, 911–912 (Readers' Forum), Dec. 1957.

The purpose of the present note is to study the effect of molecular vibration on the recovery temperature in plane Couette flow with the temperature range of interest between 600 K and 3000 K. From author's summary

4139. Syogo, M., On the Mach number at the diffuser throat of an ejector according to the hydraulic analogy, *J. aero. Sci.* **24,** 12, 918–919 (Readers' Forum), Dec. 1957.

Wave Motion in Fluids

(See also Revs. 3913, 4070, 4222, 4223, 4224, 4315)

4140. Ippen, A. T., and Kulin, G., The effect of boundary resistance on solitary waves, *Houille blanche* **12,** 3, 401–407, July/Aug. 1957.

Authors, after stating main results of available theory regarding attenuation of solitary waves, describe results of experimental investigation of attenuation in channel under different conditions. Experimental results are discussed generally and in light of those theoretical results which are available. J. K. Lunde, Norway

4141. Veltkamp, G. W., The effect of a stationary windfield on a rotating shallow sea (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 324–330.

Paper is a rather elegant mathematical treatment of behavior of a shallow coastal sea under wind action. Author shows that inclusion of Coriolis term in two-dimensional (horizontal) equations of motion can result in water elevation 112% of that with steady wind neglecting Coriolis term. R. C. Staley, USA

4142. Lauwerier, H. A., On the nonstationary behavior of a rotating shallow sea under influence of a windfield (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 331–340.

Author gives a pleasing and carefully developed mathematical treatment of piling up of coastal waters by wind action. An infinitely wide shallow sea with onshore wind normal to the coastline is treated for constant wind and for periodic wind. For an infinite sea author notes that Coriolis effect will be important, while for a small rectangular sea (a common treatment of the North Sea) the Coriolis effect will be lessened.

R. C. Staley, USA

4143. Ofitserov, A. S., Wave investigations of harbor water levels (in Russian), *Trudi Gidravl. labor. Vses. n.-i, in-ta vodosnab. kanaliz. gidrotekhn. sooruzh. i inzh. gidrogeol.* no. 4, 4–28, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1940.

Results are set out of tests carried out in the laboratory to investigate the influence of alterations in construction of protective installations of a harbor on the wave system of its sea water storage.

It is noted that the construction of the portions of the outer side of the protective installations adjoining the harbor gates when sloping reduces the wave turbulence in the approach portion and in the gates. The equipment of mainly sloping or filled-in inner sides for the protective installations causes the damping of the "wandering" waves, significantly lowers the wave amplitude on the sea water storage level of the harbor, and increases the wave regularity in the harbor. The expediency was also established of installations of asymmetrical and covered gates for the harbor.

S. V. Zhak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4144. Boss, P., Pressure impact problems—investigations in the laboratory and in actual working plants (in German), *Gas u. Wasserfach* **98,** 22, 548–552, 1957.

Water-hammer phenomena occurring in hydraulic conduits are explained, and the laboratory set up for their experimental investigation is described. The calculation of pressure and velocity relationship is very complicated, especially in case of piping systems having branch lines; graphical methods are much simpler and clearer. For measurement of pressure waves, mechanical recording indicator or electrical resistance pickups can be used; advantages and disadvantages of such instruments are discussed. Experiments were made on polyethylene tubes, of various wall thickness, with low and high water temperatures; diagrams of pressure waves are shown, and significant differences explained. Transparent model (of Plexiglas tube) was made of underwater conduit for a turbine power plant, whereby the negative pressure and generation of vapor bubbles by sudden closure of conduit valve could be visually observed. Pressure measurements were taken also at a large hydraulic power plant, having a head of about 100 feet, and a maximum flow of about 3000 cfs. Indicator diagrams taken with both a mechanical and an electrical indicator are shown and compared. Pressure fluctuations in a pump conduit, 3500 m long, at sudden stoppage of pump were measured and compared with the computed values, showing good agreement.

K. J. DeJuhasz, Germany

Turbulence, Boundary Layer, etc.

(See also Revs. 4128, 4219, 4260, 4263, 4302, 4304, 4311)

4145. Jack, J. R., Wisniewski, R. J., and Diaconis, N. S., Effects of extreme surface cooling on boundary-layer transition, *NACA TN* 4094, 19 pp., Oct. 1957.

This comprises an experimental investigation of the combined effects of boundary-layer cooling, pressure gradients, nose blunting, and surface finish on boundary transition on sharp cone-cylinders, sharp parabolic cone-cylinders, blunt cone-cylinders, hemispherical cone-cylinders and 120-in. cone-cylinders at Mach 3.12, and Reynolds number up to 15 million. Surface roughness varied from 4 to 1250 microinches. Moderate cooling delayed transition, as expected from stability theory. Extreme cooling resulted in transition reversal in which the transition Reynolds number decreased with decreasing surface temperature. Under extreme cooling, favorable pressure gradients, nose blunting and surface finish all had adverse effects on transition. The location of transition was determined in most cases from oscilloscope traces of temperature. An attempt was made to qualitatively explain the effects in terms of surface finish. Van Driest (according to Eckert) has been unable to duplicate these results. It is apparent that this problem merits much more study.

R. J. Mindak, USA

4146. Bray, K. N. C., Some notes on shock-wave boundary-layer interactions, and on the effect of suction on the separation of laminar boundary layers, *Aero. Res. Counc. Lond. curr. Pap.* 332, 7 pp. + 6 figs., 1957.

The ratio of mean velocity in the boundary layer to free-stream velocity is chosen as a parameter of the boundary-layer profile. The properties of any boundary layer are then expressed in terms of three functions of this parameter, which are independent of Mach number and Reynolds number. Using these functions, the interaction of shock waves with the boundary layer without and with suction is calculated. Under some assumptions which are physically not quite attainable (e.g., $Re \longrightarrow \infty$, boundary layer laminar and small), it is found that to cause separation a boundary layer with an asymptotic suction profile probably requires nearly three times as large a pressure change of the shock wave as a comparable unsucked boundary layer. A. Betz, Germany

4147. Rubesin, M. W., and Pappas, Constantine C., An analysis of the turbulent boundary-layer characteristics on a flat plate with distributed light-gas injection, *NACA TN* 4149, 27 pp. + 12 figs., Feb. 1958.

Authors consider the specific case of an injection of a gas (different than air) into turbulent boundary layer in air along a flat plate. Fundamental equations of turbulent boundary layer are adjusted to a binary gas system. The well-known Reynolds analogy between heat transfer and skin friction is modified so that with various simplifications the effect of injection on the skin friction and heat transfer is evaluated. The mixing theory is used and the numerical results and diagrams show that, for reducing skin friction by injection, helium and hydrogen are 2.5 and 5.0 times as effective as air; for reducing Stanton number helium and hydrogen are 2.4 and 5.2 times as effective as air. The temperature-recovery factor seems not to be affected by injection. M. Z. v. Krzywoblocki, USA

4148. Preston, J. H., The minimum Reynolds number for a turbulent boundary layer and the selection of a transition device, *J. Fluid Mech.* **3,** 4, 373–384, Jan. 1958.

In the case of turbulent flow in a pipe there is a lower experimental limit to the Reynolds number for which fully developed turbulent flow occurs. From the similarity and close agreement of the curves showing the coefficient of skin friction c_f as a function of the Reynolds number R_θ (based on the momentum thickness θ) for the circular pipe and flat plate, it is suggested that there should be a lower limit to R_θ for fully developed turbulent flow on a flat plate. Rather limited experimental data confirm this and place the lower limit at $R_\theta = 320$. The choice and size of transition device is examined in relation to this minimum R_θ, and an approximate theory leads to a "wire" Reynolds number in fair agreement with experience.

From author's summary by E. A. Brun, France

4149. Carstens, M. R., Transition from laminar to turbulent flow in a pipe, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (J. Hydr. Div.), Pap. 1450, 31 pp., Dec. 1957.

Transition from laminar to turbulent flow was experimentally observed during flow establishment in a smooth straight pipe. It was determined that (a) transition occurs in spots, (b) transport velocity is that of centerline velocity of laminar flow, and (c) observed results are in qualitative agreement with laminar boundary-layer stability theory. J. S. Marcus, USA

4150. Carstens, M. R., Transition from laminar to turbulent flow during unsteady flow in a smooth pipe (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 370–378.

Velocity-time and pressure-time measurements of the boundary-layer development in a smooth pipe are described. Transition was observed to occur in spots, starting at Reynolds numbers in approximate agreement with the theoretical values for a flat plate.

J. V. Becker, USA

4151. Whitcomb, R. T., Special bodies added on a wing to reduce shock-induced boundary-layer separation at high subsonic speeds, *NACA TN* 4293, 15 pp. + 7 figs., June 1958.

The basic test configuration had a relatively thick 35° swept-back wing of aspect ratio 7.05 mounted on a contoured fuselage. Studies of the boundary-layer flow indicate that addition of the bodies resulted in a significant lessening of the separation on this configuration at high subsonic Mach numbers. Marked reductions in drag and pitch-up were associated with the improved flow. With an increase in sweep of the wing to 40°, the effectiveness of the added bodies in improving the drag and pitching-moment characteristics was increased.

From author's summary

4152. Spreemann, K. P., Effectiveness of boundary-layer control, obtained by blowing over a plain rear flap in combination with a forward slotted flap, in deflecting a slipstream downward for vertical take-off, *NACA TN* 4200, 8 pp. + 16 figs., Feb. 1958.

The wing employed in this investigation had a 67-percent-chord slotted flap in combination with a 33-percent-chord plain rear flap equipped with a full-span blowing nozzle. The tests were conducted in a static-thrust facility at the Langley Aeronautical Laboratory. The investigation indicated that the plain rear flap alone with a low momentum coefficient for boundary-layer control provided larger turning angles than the combined slotted and plain flaps without boundary-layer control.

From author's summary

4153. Corrsin, S., Statistical behavior of a reacting mixture in isotropic turbulence, *Phys. of Fluids* **1,** 1, 42–47, Jan./Feb. 1958.

The problem of mixing by isotropic turbulence, to which the author has made a number of important contributions, is generalized by considering the effect of a simple chemical reaction on a concentration field. The investigation is purely theoretical.

To simplify the problem it is assumed: (1) The velocity and concentration fluctuations are isotropic and homogeneous. (2) One of the reactants is highly diluted so that the rate constant and

physical properties do not change as the reaction proceeds. Author suggests these assumptions could hold in dilute solutions.

First- and second-order reaction rates are considered. For a first-order reaction the problem is linear and an explicit solution is obtained in terms of the turbulence spectrum. For a second-order reaction higher moments are introduced by the reaction rate term. It is necessary to terminate the process by an assumption about the higher-order moments. Furthermore, the nonlinear reaction is expected to alter the spectrum of turbulence.

Solutions for a number of simplifying assumptions are exhibited and discussed.

A minus sign is omitted in Eq. [8] but is restored in Eq. [9] and subsequent results are not affected. W. Squire, USA

4154. Van der Hegge Zijnen, B. G., Measurements of the intensity, integral scale and microscale of turbulence downstream of three grids in a stream of air, *Appl. sci. Res.* (*A*) **7,** 2/3, 149–174, 1958.

Paper presents some new data on longitudinal turbulence level and on scales of turbulence, and compares with some data published by previous experimentors for somewhat different grids. Although, as pointed out by the author, the new data are neither extensive nor accurate enough to provide a basis for comparison with theory, nevertheless the detailed description of experimental procedure will be welcome to readers just starting to use hot-wire anemometers. S. Corrsin, USA

4155. Roberts, P. H., On the application of a statistical approximation to the theory of turbulent diffusion, *J. Math. Mech.* **6,** 6, 781–799, Nov. 1957.

The diffusion of an arbitrary property into an incompressible, stationary, homogeneous and isotropic turbulence field is studied from the Eulerian viewpoint. Equations are derived for a number of correlation tensors and transformed to wave number space. The process is terminated by making an assumption which relates the fourth-order correlation tensor to those of lower order. The assumption is analogous to one frequently used in the theory of hydrodynamic turbulence.

It is shown that in principle the equations can be solved if the spectrum of the turbulence is given, but "To solve the problem in any particular case would involve more labour than the author is willing to undertake---."

Paper is highly mathematical and of limited interest to the practical engineer. W. Squire, USA

4156. Milliat, J. P., Study of the turbulent flow in a weakly divergent channel (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 419–434.

Investigation of a two-dimensional channel flow, in air, with angles of 2, 4, and 6 degrees, and at Reynolds' numbers of the order of 40,000. Measurements of mean velocity profile give the friction velocity. A single hot-wire anemometer, normal to the mean flow, is used to determine the longitudinal velocity fluctuation, the integral scale, microscale, skewness and kurtosis of the derivative and some aspects of the second derivative. The intermittency of the first and second derivatives are determined, as functions of the distance from the wall, and these interesting results support the idea of "turbulent flashes." (In the last table, read γ_T for T and γ_{T_1} for T_1 in columns 4 and 5.)
R. Betchov, USA

4157. Tatsumi, T., The energy spectrum of incompressible isotropic turbulence (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 396–404.

Author continues calculations already reported [AMR **10** (1957), Rev. 2983] on the decay of isotropic turbulence, using the assumption of zero fourth-order cumulant of the velocity field. The new feature is that he shows how to obtain the spectrum function as a power series in the Reynolds number of the turbulence, each coefficient being a function of time. The coefficients of the first two terms (proportional to R^0 and R^2) are found explicitly for an initial spectrum which is zero everywhere except at one wave-number magnitude. The first of these terms exhibits pure viscous damping of the initial "line" spectrum, and the second shows some of the nonlinear inertia effect, including a transfer of energy from the "line" to a continuous (and finite) range of wave numbers. The author calculates the rate of decay of total energy and the form of the spectrum at both small and large values of the time, so far as they are given by the first two terms of the power series in R^2. G. K. Batchelor, England

4158. Malkus, W. V. R., Outline of a theory of turbulent transport processes (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 388–395.

Author introduces a new hypothesis in the theory of turbulent shear flow: The rate of dissipation of potential energy into heat is a maximum subject only to stability constraints. He applies this to two specific cases: to the momentum transport and the turbulent convection in flow between two parallel walls. The first case is treated in a much more detailed form in an earlier publication [AMR **10** (1957), Rev. 4101]. J. Laufer, USA

4159. Bjorgum, O., On a mathematical theory of shear-flow turbulence (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 379–387.

This is a discussion in general terms of some of the mathematical aspects of turbulence. The first half of the paper shows how, in a plane parallel laminar flow which is unstable, the growth of a sinusoidal disturbance leads in turn, through the action of nonlinear terms, to the generation of other Fourier components of the disturbance; all these disturbance components have an effect on the mean velocity profile. In the second half the author presents some analysis based on the hypothesis that the mean velocity profile of a statistically steady turbulent flow is such that all Fourier components of a linearized disturbance are neutrally stable. G. K. Batchelor, England

4160. Shigemitsu, Y., Statistical theory of turbulence, I Hypothesis of vortex chaos motion, *J. phys. Soc. Japan* **10,** 6, 472–482, June 1955.

Author proposes to represent two-dimensional turbulent motion by a random distribution of overlapping "vortices," each vortex having an axisymmetric velocity distribution of the kind produced by viscous diffusion of vorticity. No results are given in this part of the paper. Reviewer notes that the basic idea is like that used by Synge and Lin [*Trans. roy. Soc. Can.* **37,** p. 45, 1943] who represented the turbulence by a superposition of Hill's spherical vortices. G. K. Batchelor, England

4161. Ashkenas, H., Turbulent shearing stress in the boundary layer of yawed flat plates, *NACA TN* 4140, 20 pp. + 1 table + 15 figs., Apr. 1958.

Hot-wire anemometer measurements of the turbulent shearing stress in a turbulent boundary layer on a yawed flat plate are presented. Two plates with angles of yaw of 0° and 45° were studied. Measurements of the intensity of turbulence were made simultaneously with the shear measurements, using a technique developed by the author. The experimental procedure is reviewed briefly and an attempt is made to evaluate the precision of the results. From author's summary

4162. Rizk, W., Experimental studies of the mixing processes and flow configurations in two-cycle engine scavenging, Inst. mech. Engrs., Preprint, 13 pp., 1958.

To obtain a better understanding of the scavenging processes in two-cycle engine cylinders, experiments are conducted with

various models and testing techniques. While most tests are conducted with water, based on the fact that the scavenging processes are mainly incompressible, in some tests smoke is used to show the flow patterns in air. By carefully determining their limitations, steady-flow conditions of jet-mixing processes are also studied and applied to the solution of the problem. From all observations, author is able to determine vortex movements in cylinders of various shapes and with various guide block arrangements and to draw conclusions for an improvement of two-cycle engines. Questions that still need an answer are indicated.

Paper gives a valuable account of the state of the art of attacking the complicated scavenging processes in two-cycle engines and should be of interest to everybody working in this field.

H. J. Ramm, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 3865, 3873, 3874, 4090, 4099, 4114, 4126, 4130, 4135, 4188, 4202, 4205, 4206, 4207)

Book—4163. Zonshain, S. I., Aerodynamics and construction of aircraft [Manual for students (other than pilot students) in special branches of aviation high school institutions] (in Russian), Moscow, Oborongiz, 244 pp. + 72 illus., 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1699.

The book has been written on the basis of a series of lectures by the author in the Moscow aviation technological institute, and is intended for use as a manual for students of the specialties of aviation in higher education institutes (other than flying instruction). The contents of the book are divided into two almost equal parts. I. Aerodynamics: §§1–6, general questions concerning aerohydrodynamics; §7, experimental methods; §§8–11, aerodynamical calculations, also including questions on the stability of the aircraft. II. Construction (and calculation for endurance); §§12–13, specific matters dealing with calculations for endurance of aeroplanes; §§14–15, constructional requirements and aeroplane planning; §§16–21, description of the construction of the basic units of aeroplanes; §22, aspects of the development of flying machines. The book concludes with an exposition of the basic principles involved in designing aircraft.

The contents of the book are not given uniformly. For instance, of the basic aerodynamic equations only those for continuity and energy are put forward, and nothing is said of the equation for movement. Some unfortunate expressions occur, also technical terms (equation of non-detachability), and, further, incorrect formulation (determination of a plane vortex, p. 14; determination of similarity, p. 50; the adiabatic process is mixed up with the isoentropic, p. 52, and others). Bernoulli's equation (p. 15) is irregularly applied. The small and end disturbances are tangled up; on p. 57 it is indicated that, in the shock transit of the Mach cone, there are changes in pressure, density, velocity and temperature. The second part of the book—construction of the aircraft—is taken up principally with a description of the basic assembly units of the aircraft.

A. I. Borisenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4164. Dorodnicyn, A. A., On a method of numerical solution of some non-linear problems of aerodynamics (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **1**, p. 485.

A method of numerical solution of some nonlinear problems of aerohydrodynamics is considered, which is applied in cases when the motion of fluid is described by elliptical equations, parabolical equations, or by equations of mixed types.

The method is based on the substitution of a system of partial differential equations by an approximating system of ordinary differential equations.

From author's summary

4165. Rethorst, S., Aerodynamics of nonuniform flows as related to an airfoil extending through a circular jet, *J. aero. Sci.* **25,** 1, 11–28, Jan. 1958.

In previous studies of the effect of propeller slip stream on lift, the downwash due to circular jet boundaries has been determined from a distribution of vortex lines of infinite length representing images of the trailing vortices; images of the bound vortices were not considered. The author eliminates this shortcoming by using images built up from series of horseshoe vortices; he decomposes these into systems of even and odd halves and treats each system independently. Application of the Weissinger lifting surface method to the combined vortex system due to wing and jet results in expressions for downwash coefficients applicable to any wing-jet geometry and velocity ratio. The results of a sample calculation corresponding to an existing experimental study show excellent agreement with experiment within the jet. Outside of the jet, valid comparisons cannot be made due to peculiarities of test-setup geometry.

A. Fejer, USA

4166. Hirsch, R., Establishment of lift on an aerofoil with a jet flap, Part I, *Aircr. Engng.* **29,** 346, 366–375, Dec. 1957.

In this part Hirsch solves the problem of the circulation, velocity distribution, and the force acting on an airfoil with a jet flap in a two-dimensional incompressible flow. As in the classical case, the complex variable technique is used. Circulation depends directly on the trailing edge condition similar to the Joukowsky condition in conventional flow. The law governing the movement of the elementary vortices in the downwash depends on the viscous damping of the vorticity. Hirsch establishes also the law of the drag of the jet behind the nozzle. The theory is applied to two cases, and a comparison is made with experimental results.

M. Z. v. Krzywoblocki, USA

4167. Hirsch, R., Establishment of lift on an aerofoil with a jet flap, Part 2, *Aircr. Engng.* **30,** 347, 11–19, Jan. 1958.

This continuation of Hirsch's work (see preceding review) generalizes the classical Prandtl theory of a finite wing to an airfoil with a jet flap. After the basic equations are established they are applied to a particular case of the elliptical distribution of the circulation. In this case an approximate solution is found. Next, Hirsch considers a wing with a fuselage. A comparison of the theory with experimental results is given in two cases: wing with fuselage and trailing edge jet; wing with trailing edge jet.

M. Z. v. Krzywoblocki, USA

4168. Dimmock, N. A., Some early jet flap experiments, *Aero. Quart.* **8,** 4, 331–345, Nov. 1957.

The "second stage" two-dimensional jet flap experiments are briefly described and some of the results presented with comments. The relative simplicity of these experiments and the measure of their agreement with the theory provides yet another illustration of the value of comparatively simple experiments in the early stages of work on a novel idea.

From author's summary

4169. Weber, J., Theoretical load distribution on a wing with a cylindrical body at one end, *Aero. Res. Counc. Lond. Rep. Mem.* 2889, 14 pp. + 9 figs., 1957.

Author states that solution is derived for arrangements giving constant induced downwash, but can be generalized to obtain approximate results for other planforms, including those with sweepback. Charts are given for the case in which the sectional lift slope is constant along the span. The lift distribution over both

wing and body can be determined quickly, or the over-all load directly. There is no comparison with experiment.

Results are applicable to a rear fuselage with fin, and a wing carrying a single drop-tank or weapon at one tip. It should be noted that one can not determine an equivalent end-plate for a cylindrical body attached to a wing since the lift distribution is different in each case.

The load distribution over wing and cylinder depends on the two-dimensional flow in the Trefftz plane which is related to that past a circular cylinder by an intermediate conformal transformation into wing with one end-plate. Both the ratio lift-on-body/lift-on-wing, and the spanwise load distribution are shown to depend only on the ratio body-radius/wing-span

This report is of interest to aerodynamicists and project designers. S. Kirkby, England

4170. Mitsuyasu, A., The influence of the sweep on the induced angle of wings, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 287–290.

Assumptions are conventional: incompressible potential flow, lifting vortices and trailing vortices in the same plane. Author avoids difficulty caused by discontinuity of lifting line tangent by calculating downwash in the wake of wing. Munk's stagger theorem is used considering the induced angle as half the value of the downwash at an infinite distance downstream. Numerical results for wing of taper ratio one and aspect ratio 2.5 are presented for 45° sweep foreward and backward.

G. W. Braun, USA

4171. Stevens, J. C., Flow through circular weirs, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (*J. Hydr. Div.*), Pap. 1455, 25 pp., Dec. 1957.

Certain advantages are inherent in the use of the circular weir. However it has not come into general usage in the United States. It is more extensively used in Europe where there has been developed a rigid accurate formula by which the flow can be determined.

A formula is presented for the theoretical flow through sharp-crested circular weirs which involves the use of elliptic functions. Most of the European treatises on such weirs are not generally available now. Tables appended give (1) a summary of available experimental data with discharge coefficients, (2) the flow through weirs of various diameters based on these coefficients, and (3) values of the elliptic functions involved by which the flow through a circular weir of any diameter may be found.

From author's summary

4172. Sinnott, C. S., Calculated velocity distributions and force derivatives for a series of high-speed aerofoils, *Aero. Res. Counc. Lond. Rep. Mem.* 3045, 8 pp. + 15 tables + 27 figs., 1957.

The polygon method of Woods is used to calculate the velocity distribution over a number of two-dimensional airfoils at low incidence, subcritical flows only being considered. Lift slopes and aerodynamic centers at zero lift are also calculated.

Some comparisons with experimental results are made, and these show good agreement at zero incidence.

From author's summary

4173. Kuchemann, D., Note on the drag due to lift of slender wings, *J. roy. aero. Soc.* **61,** 558, 423–424 (Tech. Notes), June 1957.

4174. Dickinson, R. P., Some possible implications of minimum drag speed at altitude, AGARD Rep. 131, 4 pp. + 4 figs., May 1957.

4175. Head, R. M., Airfoils derived from an elliptic cylinder (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **1,** 434–438.

4176. Weinig, F. S., Computation of drag in separated flow by use of rolling up free streamlines (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **1,** 215–220.

4177. Fail, R., An experimental investigation of the flow past flat plates of various shapes normal to the wind stream (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **1,** 420–425.

4178. Lean, D., and Eaton, R., The influence of drag characteristics on the choice of landing approach speeds, AGARD Rep. 122, 12 pp. + 2 tables + 9 figs., May, 1957.

A study has been made of the lift-drag characteristics of 19 jet aircraft which have minimum comfortable approach airspeeds that are fairly well established. On about half these aircraft, drag effects, which determine speed stability, were stated to limit the approach airspeeds, though there was naturally some lack of unanimity as to the level of the effect which could be classed as tolerable. Limiting values of speed stability are proposed for the three types of landing approach used for carrier, airfield, and instrument landings. The speeds corresponding to these stability levels are in fair agreement with those actually used, even for those aircraft whose approach speeds were not primarily limited by drag effects. It is considered that drag effects must be taken into account in estimating approach airspeeds, and that this process materially improves the prediction of approach speeds for the latest types of aircraft.

Further data should be collected and analyzed in order to confirm or modify the form or level of the proposed limits.

From authors' summary

4179. Wolkovitch, J., Fins, *J. roy. aero. Soc.* **61,** 564, 815–818, Dec. 1957.

Judging by the number of present-day aircraft which have suffered changes of fin shape, it is clear that there is still some difficulty in estimating the size and shape of fin required on a new project. In this paper some of the principles on which fin design is based are explained, and some of the difficulties involved are described. From author's summary

4180. Crabill, N. L., An analytical investigation of the gust-alleviating properties of a simple pitch damper, *NACA TN* 4173, 47 pp., Dec. 1957.

Author calculates response of lightly pitch-damped (25% of critical with fixed elevator) airplane at $M = 0.7$ to discrete and continuous gustiness. Model is supplied with mass-overbalanced elevator and various amounts of viscous hinge damping. Maximum pitch damping of about 82% critical is realized for elevator rotational velocity hinge-moment coefficient of about twice "critical-magnitude." At about this value, a maximum 20% reduction in rms acceleration response to continuous gustiness is realized. Due to methods used, analysis shows no reduction in peak acceleration response to "discrete" gust. There are indications of improvement by way of decreased rotational velocity and reduction in post-entry acceleration peaks. P. R. Hardesty, USA

4181. Smith, A. G., Warren, G. H. E., and Wright, D. F., Investigations of the behaviour of aircraft when making a forced landing on water (ditching), *Aero. Res. Counc. Lond. Rep. Mem.* 2917, 28 pp. + 25 figs., 1957.

4182. Ridland, D. M., Investigation of high length/beam ratio seaplane hulls with high beam loadings (Hydrodynamic stability Part 20). The effect of slipstream on stability and spray characteristics, *Aero. Res. Counc. Lond. curr. Pap.* 349, 15 pp. + 3 tables + 16 figs., 1957.

The effects of slipstream on longitudinal stability, spray, and elevator effectiveness are deduced from tests on four configurations of the basic model of the series which differed only in aerodynamic details.

It was found that, in general, increases in thrust coefficient improved longitudinal stability, spray characteristics, and elevator effectiveness. A method of applying the detailed results to the stability limits of other models of the series is outlined.

From author's summary

4183. Friswell, J. K., Investigation of high length/beam ratio seaplane hulls with high beam loadings, (Hydrodynamic stability Part. 19). The interaction of the effects of forebody warp, afterbody length and afterbody angle on longitudinal stability characteristics, *Aero. Res. Counc. Lond. curr. Pap.* 352, 14 pp. + 16 figs., 1957.

In this report the interaction of the effects of the different parameters concerned in the investigation is considered. It is found that by a redefinition of stability it is possible to predict these interactions as far as the undisturbed lower limit is concerned, but that otherwise there seems to be no simple law governing them. Some broad generalizations are, however, possible.

From author's summary

4184. Vleghert, J. P. K., Measuring climb performance of a propeller engined transport aeroplane using the accelerator technique, *AGARD Rep.* 127, 6 pp. + 4 figs., + append., May 1957.

4185. Pinsker, W. J. G., The flight simulator in aircraft control and design, *AGARD Rep.* 71, 16 pp. + 15 figs., Aug. 1956.

4186. Lewis, W., and Perkins, P. J., Jr., A flight evaluation and analysis of the effect of icing conditions on the ZPG-2 airship, *NACA TN* 4220, 33 pp. + 1 table + 26 figs., Apr. 1958.

Test flights conducted by the U. S. Navy in a number of typical icing conditions are described. The airship operated successfully in all icing conditions encountered, but the desirability of limited protection for certain components was indicated. Icing in clouds was confined to wires and small components, but freezing rain and drizzle produced some icing on the envelope also. Theoretical calculations are presented which suggest that, while hazardous icing in freezing rain can occur under certain meteorological conditions, the probability of encountering these conditions is very small in coastal areas and approaches zero 200 to 300 miles offshore.

From authors' summary

4187. Blackburn, A. W., Flight testing stability augmentation devices for high-performance fighters, *Aero. Engng. Rev.* **16,** 9, 75-82, Sept. 1957.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 4112, 4209)

4188. Van de Vooren, A. I., Unsteady airfoil theory; Advances in appl. Mech. (edited by Dryden, H. L., and von Karman, Th.), Academic Press, 1958, pp. 35-89.

For flutter analysis as well as for gust response problems, study of the effects of nonstationary motions and deformations of airfoils has become more and more important during the past 30 years. This has resulted in a large number of papers on flutter derivatives from oscillating airfoil theory and, for arbitrary motions of the airfoil, on so-called indicial functions which describe the time dependence of the pressure distribution due to a unit-step change of one of the variables (e.g. the angle of attack). The governing equation—the basic equation of aerodynamics and gasdynamics with time dependent variables—can be solved approximately only and is in general reduced to the wave equation for incompressible flow.

After discussing conditions for linearization and application of small-disturbance theory, author reviews available methods of solution in the different domains of Mach number and airfoil shape. Treatment is restricted to motion of one airfoil only. A large bibliography contains illustrative references to all important methods until about 1955.

Transformations of the basic equations, boundary, and wake conditions are contained in Chap. II together with a short review on reciprocity relations. Some nonlinear extensions of unsteady airfoil theory are found in Chap. VII, mainly van Dyke's second-order theory and aspects of piston theory for use in hypersonic flow.

Chapters III-VI contain linear oscillating airfoil theory. For two-dimensional subsonic flow, the method of the velocity potential, the acceleration potential, and the integral equation are given, also some semi-empirical methods. In three-dimensional subsonic flow, the circular wing and several approximations for wings of high and low aspect ratio are discussed. Not included are analogy solutions or "lifting line" methods. For supersonic flow, airfoils with supersonic edges, the moving-source method, Riemann's method, and Fourier transformation methods are given. For supersonic flows—airfoils with subsonic edges—analytical methods are given for the rectangular and the delta wing and several numerical methods for wings of arbitrary shape. No results are given for the transonic range.

In Chap. VIII there is a very brief summary of methods of calculation for indicial functions and their connection with flutter derivatives, including equations for calculating flutter derivatives from indicial functions and vice versa.

Author's presentation of this difficult and very complex subject is very clear and well organized and the main ideas of the different methods of approach mentioned are formulated excellently. There is however a certain lack of critical comments both as regards applicability of the method in question for calculation of numerical results, limits of validity, and comparison between different methods quoted in the same flow airfoil-shape regime.

Altogether, the paper in its mainly mathematical presentation should be more suited for the research scientist than for the engineer, especially as lack of space apparently prevented more detailed discussion of physical background, implications of the different approximations in the basic equation and the boundary and edge conditions, and results of numerical calculations from the different methods.

H. Merbt, Sweden

4189. Jordon, P. F., The harmonically oscillating wing with finite vortex trail, *Aero. Res. Counc. Lond. Rep. Mem.* 3038, 14 pp. + 2 tables + 4 figs., 1957.

The wing of infinite span oscillating harmonically in incompressible flow but having a vortex trail of finite length is discussed theoretically. The "incomplete circulation function" which arises in this case is tabulated. As an example the damping moment due to slow pitching oscillations is shown for several values of the length of the trail. The result is of interest as a wind-tunnel correction, in particular in that range of small frequencies which occurs in flight stability oscillations.

Agreement with an experiment in an open-jet wind tunnel is obtained. A contradiction between different experiments in closed-jet wind tunnels is mentioned.

From author's summary by M. Botman, Canada

4190. Kussner, H. G., Theory of the oscillating elliptical airfoil in subsonic region (in German), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 75-84.

A method of solution is presented for the elliptic wing using curvilinear orthogonal coordinates. The solution is in terms of Lamé functions. Author uses in his derivations a property which, in reviewer's opinion, is false. It is stated that the exact solution in linearized airfoil theory can be written in the form

$$\varphi(x,y,z) = \iint_{\text{wing}} w(x',y')\, K(x-x', y-y', z)\, dx'\, dy',$$

where the kernel K is a difference kernel depending upon $x - x'$ and $y - y'$. The integration is over the wing surface, where the downwash $w(x',y')$ is given. According to reviewer this statement holds only for a wing with supersonic edges and provided the point x,y,z is not affected by the wake. In all other cases the kernel will be a difference kernel only if the integration is also extended over the regions of upwash and downwash aside and aft of the wing. If the integration area is restricted to the wing, the kernel will, in general, not be a difference kernel, as can be verified easily for two-dimensional steady flow.

A. I. van de Vooren, Holland

4191. Krasilchtchikova, E. A., Method of integral equations in the thin wing theory in a compressible medium (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 57-67.

Paper deals with the problem of a harmonically oscillating wing which, in addition to subsonic edges, contains a leading edge which is at least partly supersonic. This is an extension to unsteady flow of what is in western countries usually known as an Evvard problem [AMR **4** (1951), Rev. 3310], which can be described by integral equations of Abel's type. Similar extension has been given by Li and Stewart [AMR **8** (1955), Rev. 479], who have presented the same solution as the present author, namely by expansions in power series to the reduced frequency. In this way the solution of the unsteady problem is reduced to the solution of a series of Abel equations of which the right-hand sides can be evaluated from the results of the preceding equations. It should be added that according to *NACA TM* 1383 (1956) the Russian author gave her solution as long ago as 1947.

A. I. van de Vooren, Holland

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 3894, 3943, 4021, 4064, 4071, 4072, 4073, 4074, 4093, 4095, 4097, 4098, 4100, 4101, 4109, 4111, 4162, 4242, 4245, 4250, 4269)

4192. Shchapov, N. M., Disregarding some facts in efficiency tests of turbines and other machines (in Russian), Energomashinostroenie, Leningrad, **3,** 10, 23-26, Oct. 1957.

Author discusses several secondary elements usually neglected in evaluation of tests, like change in the specific weight of water with pressure, temperature, silt content, in the gravity acceleration with latitude and altitude, in the discharge measurement under pressure, in the expansion of penstock walls, etc. Small systematic errors tend to accumulate and cannot be neglected.

S. Kolupaila, USA

4193. Nemm, V. A., Experimental investigation on the strength of the component parts of a hydroturbine (in Russian), Gidroturbostroenie, no. 1, Moscow-Leningrad, Mashgiz, 1955, 194-209; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2440.

A description is given of the experimental investigation of the stresses in the components of turbine PL-587 intended for use by the Kuibyshev. and Stalingrad GES: the blades of the working wheel (model 1/20th of full scale, made of L-30 steel, at an evenly distributed load of 5kg/cm^2), the casings of the working wheel, and the cylinders of the servomotor (full scale, at an internal pressure of 40 atm) and the welded regulating ring (St. 3, model 1/5th full scale, on a special appliance, representing the force from the servomotors). The measurement of the stresses was made using electric strain gages, and the paths of the principal stresses were determined using coatings.

N. A. Kartvelishvili
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4194. Kirillov, I. I., The experimental single-stage air turbine of the Laboratory for Turbo-design, Bezhitskii Institute of Transport Engineering (in Russian), *Trudi Bezhitsk. inta transp. mashinostr.* no. 15, 46-50, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6557.

Examination of the effective methods of organization of a flow in the stages of a working steam turbine with relatively long blades. For those relationships of the mean diameter of the wheel to the height of the blade at which it is expedient to have the blades warped, stages of constant circulation with location of the root sections of the blade on one diameter are recommended.

In the case of displacement of the root sections, the stage of reactivity and of the profile should be the same in them as in the last stage of diameters equal to the diameters of the root sections.

The use of these stages makes it possible to use blades with single-type root sections.

N. A. Kolokol'tsov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4195. Wilson, W. K., and Harris, W. J., Gyroscopic loading tests on a gas turbine rotor, Instn. Mech. Engrs. Lond., Preprint 16 pp.

4196. Vadot, L., Water pumping by windmills (in English), *Houille blanche* **12,** 4, 524-535, Sept. 1957.

4197. Wattendorf, F. L., von Ohain, H., and Lawson, M., Factors influencing operating limits of high flux axial compressors (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 309-319.

From consideration of flow coefficient fluctuations of the first and last stages of a single-spool multistage axial compressor over the entire speed range, authors show the desirability of utilizing flat characteristics for these stages. Types and principal aspects of stages with flat characteristics are discussed in relation to the operational range of a compressor as a major design requirement. Suggested method of optimization of stage characteristics and stage matching indicates at least a theoretical possibility of designing highly loaded axial compressors with wide operational ranges and with favorable efficiency. An example of a three-stage compressor with 8:1 pressure ratio illustrates the application of the discussed method.

C. P. Kentzer, USA

4198. Schulze, W. M., Erwin, J. R., and Ashby, G. C., Jr., NACA 65-series compressor rotor performance with varying annulus-area ratio, solidity, blade angle, and Reynolds number and comparison with cascade results, *NACA TN* 4130, 19 pp. + 1 table + 35 figs., Oct. 1957.

An axial-flow compressor rotor was tested at low speed and without guide vanes or stators in a 28-in. test compressor. The rotor was designed for a free-vortex-type blade loading using NACA 65-series 10-percent-thick airfoil sections. In these tests, the effects of changes of blade-setting angle, annulus-area ratio,

solidity, and Reynolds number on rotor performance were determined for a range of quantity flows. Rotor data are compared with estimations based on uncorrected and corrected cascade data.

From authors' summary

4199. Reynolds, R. M., Sammonds, R. I., and Walker, J. H., An investigation of single and dual-rotation propellers at positive and negative thrust, and in combination with an NACA 1-series D-type cowling at Mach number up to 0.84, *NACA Rep.* 1336, 58 pp., 1957.

The results presented include propeller force characteristics, local velocity distributions in the propeller planes, inlet pressure recoveries, and static-pressure distributions on the cowling surfaces measured for a wide range of blade angles, advance ratios, and inlet-velocity ratios for the NACA 4-(5)(05)-041 four-blade, single-rotation propeller and the NACA 4-(5)(05)-037 six- and eight-blade, dual-rotation propellers in various combinations with NACA 1-series spinners, extended cylindrical spinners, and NACA D-type spinner cowlings. From authors' summary

4200. Gail, A., The ramprop, a supersonic jet-driven propeller (in German), *Z. Flugwiss.* **4,** 11, 341-355, Nov. 1956.

The ramprop is a propulsion system consisting of rotor blades driven with supersonic speed by ramjets or ramrockets at the blade tips. The structural and aerodynamic problems of ramprops are analyzed and a suitable design is proposed. The ramprop is found to be a very promising powerplant for large convertible aircraft capable of vertical take-off and descent, transonic cruising flight, and useful load capacity corresponding to conventional transport aircraft. From author's summary

4201. Slotboom, J. G., The behaviour of a gaslift pump for liquids (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 371-383.

Author outlines a theory of flow in gaslift pumps in order to give an approach as rational as possible to design and operation problems of such apparatus.

Recourse is had to known relations, valid for the motion of unconfined air bubbles in tubes filled with liquid and for pure liquid flow. After making the necessary approximations, an equation valid for "piston type flow" in the pump is obtained, which relates the liquid discharge to the amount of gas flow, the head on the pump, the diameter of the pump, and the properties of the liquid.

Reading of the article is plain and easy; more clarity in the definition and use of symbols and units, particularly concerning density and specific weight, would have been desirable.

P. L. Romita, Italy

4202. Baxter, A. D., Aero-engines: past, present and future, *Instn. mech. Engrs. Proc.* **171,** 1, 83-92, 1957.

Flow and Flight Test Techniques

(See also Revs. 4108, 4181, 4185, 4187, 4189, 4193, 4194, 4298)

Book—4203. Lobachev, P. V., and Shevelev, F. A., Water meters for water supply and sewerage (in Russian), Moscow, Gosstroĭizdat, 1957, 292 pp.

A textbook on water meters for practice discusses types, rating and use; volumetric, tachometric types; contraction meters: throats, nozzles, diaphragms; partial meters; elbows; measurements by local velocity; transportable meters; control and calibration. This complete and carefully edited textbook is based almost exclusively on Russian instruments and devices. Foreign names are mentioned only in connection with elbows.

S. Kolupaila, USA

4204. Tikhmenev, S. S., Apparatus for powered temperature bimetallic compensation (in Russian), Elements of calculation for precision apparatus, Moscow, Oborongiz, 1954, 5-24; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2573.

The calculation is described for a powered temperature bimetallic compensation for sensitive manometer elements of apparatus as exemplified by aneroid and manometer membrane boxes. The question is examined of the selection of the dependence of the compensatory stress on the travel of the sensitive element. It was shown that full temperature compensation is only possible, in the general case, on two points of the characteristic of the sensitive element. In deducing the formulas, simplifications were introduced, following customary practice in calculations by the method of resistance of materials. Cases of rectangular and trapezoidal bimetallic plates were studied, and a grapho-analytical method was given for the selection of the constructional parameters of compensation. L. E. Andreeva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4205. Riebe, J. M., and Davenport, E. E., Exploratory wind-tunnel investigation to determine the lift effects of blowing over flaps from nacelles mounted above the wing, *NACA TN* 4298, 9 pp. + 1 table + 8 figs., June 1958.

An exploratory investigation, in which high-pressure air was blown over single and double slotted flaps from externally supported steel-pipe nacelles above the wing to simulate jet-engine exhaust, has been conducted on a model with a delta wing of aspect ratio 3. The jet-momentum-coefficient range was from 0 to 3.0 and the model angle of attack was 0°. Results of the limited investigation show that jet-circulation lift coefficients greater than the jet reaction alone were produced.

From authors' summary

4206. McKee, J. W., and Naeseth, R. L., Experimental investigation of the drag of flat plates and cylinders in the slipstream of a hovering rotor, *NACA TN* 4239, 12 pp. + 1 table + 19 figs., Apr. 1958.

An experimental study has been made of the drag of flat plates and cylinders in the slipstream of a rotor for the condition of hovering away from the effect of the ground. Random fluctuations and a very nonuniform average radial distribution of dynamic pressure existed in the slipstream. The drag of constant-chord models spanning the rotor disk was relatively unaffected by distance from the plane of the rotor. An attempt to compare model drag coefficients with values obtained from wind-tunnel tests led to rather inconclusive results, particularly for the cylinders.

From authors' summary

4207. Pinsker, W. J. G., Flight tests on a Vampire Mk. 5 with a redesigned anti-snaking rudder, *Aero. Res. Counc. Lond. Rep. Mem.* 3014, 7 pp. + 1 table + 26 figs., 1957.

A specially designed rudder has been fitted to a Vampire Mk. 5 to act as an aerodynamic yaw damper. Flight tests show that the damping of the lateral oscillation has been substantially increased in consequence, a logarithmic decrement greater than unity being attained even at 40,000-ft altitude.

This is a considerable improvement on the results obtained previously on the same aircraft, when the standard rudder was used as the damping surface.

Air-to-air aiming is shown to have benefited from the effect of the damping rudder. From author's summary

4208. Garner, H. C., and Acum, W. E. A., Interference corrections for asymmetrically loaded wings in closed rectangular wind tunnels, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2948, 38 pp., 1957.

Authors work out the corrections to be applied to the measured forces and moments on a wing with deflected ailerons in a wind tunnel having a closed, rectangular working section.

The antisymmetric part of the lift distribution on the wing is represented by a special system of horse-shoe vortices, and the upwash distribution induced by their images in the tunnel walls is found in terms of certain functions tabulated in the paper. Multhopp's lifting surface theory is suggested as a convenient method of relating the lift distribution in the tunnel to the measured rolling moment and of deducing from the induced upwash the corresponding distribution in an unconstrained stream. A simple method based partly on lifting-line theory is alternatively put forward, and this appears to be successful for a particular example considered in the paper.

The method is illustrated numerically for the case of an arrowhead wing in a wind tunnel at the National Physical Laboratory.

P. R. Owen, England

4209. Jones, W. P., Wind-tunnel wall interference effects on oscillating aerofoils in subsonic flow, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2943, 21 pp., 1957.

Author calculates the aerodynamic forces on a thin airfoil spanning a subsonic wind tunnel of rectangular section and performing pitching and plunging oscillations. The calculations take account of the compressibility of the air and are restricted to frequencies below a certain value at which, depending on Mach number and ratio of airfoil chord to tunnel height, resonant transverse oscillations of the airstream may occur.

Paper gives numerical examples of the aerodynamic derivatives for a flat plate at $M = 0.7$ and of chord roughly 1/5th of the tunnel height. They show that the tunnel wall constraint is considerable even in the range of low frequencies examined; it would be expected to be large at frequencies near that of resonance.

Comparison is made between the pitching moment damping coefficient for a certain airfoil as predicted by the theory and as measured in a wind tunnel by Bratt. Discrepancies are noted, but they can be reduced by applying author's "equivalent profile technique."

P. R. Owen, England

4210. Lightfoot, J. R., and White, C. E., Special applications of strain-gage balances used in the supersonic and hypersonic wind tunnels at the U. S. Naval Ordnance Laboratory, *AGARD Rep.* 8, 13 pp., Feb. 1956.

4211. Hansen, R. M., Mechanical design and fabrication of strain-gage balances, *AGARD Rep.* 9, 14 pp., Feb. 1956.

4212. Development of half-model wind-tunnel balances, *AGARD Rep.* 10, 28 + vii append., Feb. 1956.

4213. Lambourne, N. C., A note on a half-model strain-gauge balance, *AGARD Rep.* 11, 7 pp., Feb. 1956.

4214. McFarland, K. H., and Dimeff, J., Problems involved in precision measurements with resistance strain gages, *AGARD Rep.* 12, 17 pp., Feb. 1956.

4215. Hausen, R. M., Evaluation and calibration of wire-strain-gage wind-tunnel balances under load, *AGARD Rep.* 13, 17 pp., Feb. 1956.

4216. Tonkin, G. P., Elevated stagnation temperature and strain gauge balances in the instrumentation of a supersonic wind tunnel, *AGARD Rep.* 15, 24 pp. + 4 tables + 36 figs., Feb. 1956.

4217. Rawlings, G. W., Precision machining techniques as applied to the manufacture of supersonic wind-tunnel models, *AGARD Rep.* 23, 9 pp. + 18 figs., Feb. 1956.

4218. Dobbinga, E., and Prast, G., Short notes on model-making and force measuring techniques, *AGARD Rep.* 18, 12 pp. + 28 figs., Feb. 1956.

4219. Gooderum, P. B., An experimental study of the turbulent boundary layer on a shock-tube wall, *NACA TN* 4243, 26 pp. + 1 table + 19 figs., June 1958.

Interferometric measurements were made of the density profiles of an unsteady turbulent boundary layer on the flat wall of a shock tube. The investigation included both subsonic and supersonic flow (Mach numbers of 0.50 and 1.77) with no pressure gradient and with heat transfer to a cold wall. Velocity profiles and average skin-friction coefficients were calculated. Effects on the velocity profile of surface roughness and flow length are examined.

From author's summary

4220. Henshall, B. D., On some aspects of the use of shock tubes in aerodynamic research, *Aero. Res. Counc. Lond. Rep. Mem.* 3044, 62 pp. + 11 tables + 83 figs., 1957.

In view of the interest the shock tube has recently gained as a short-duration wind tunnel or for the study of transient phenomena, a survey of existing shock-tube theory and an analysis of experimental results may be extremely useful. As a first step author formulates a basic ideal shock-tube theory in detail and develops a rapid method for the aerodynamic design of a conventional shock tube, including performance charts. Experimental results diverge from the simple ideal theory principally because of the presence of viscous effects and the finite bursting time of the diaphragm. Careful analysis of available experimental data yielded a series of important parameters, which should be incorporated in any modified theory of shock-tube flow.

In a new analytical approach the effect of laminar boundary-layer growth on the walls of the tube has been investigated approximately by using the Polhausen method. The contact surface was found to accelerate and this may be shown to be accompanied by a retardation of the shock wave.

As a parallel study, the design and construction of a shock-tube installation was undertaken. Low cost was obtained by using mahogany for the shock tube of 34-ft length and 6-in. by 2 1/2-in. cross section. Ancillary equipment was developed for the installation, and particular attention was given to the optical and electronic equipment. A detailed calibration of the shock tube was carried out and timed photographs of the transient diffraction of a shock wave over a wedge were obtained.

In conclusion the probable future development and uses of shock tubes in aerodynamic research are discussed in the light of recent experimental and theoretical work.

W. Wuest, Germany

4221. Ludi, L. H., Flight investigation of effects of atmospheric turbulence and moderate maneuvers on bending and torsional moment encountered by a helicopter rotor blade, *NACA TN* 4203, 12 pp. + 1 table + 12 figs., Feb. 1958.

Experimental studies of the effects of atmospheric turbulence and moderate maneuvers on the steady and periodic rotor blade moments encountered by a single-rotor helicopter show that atmospheric turbulence and control motions do not produce additional periodic blade moments, except when accompanied by center-of-gravity accelerations, significant to fatigue calculations during the principal part of the flying time. This information permits the use of time spent, as determined by an NACA helicopter VGHN recorder, in conjunction with prototype strain measurements as a basis for that portion of the cumulative fatigue analysis that covers the principal part of the flying time.

From author's summary

4222. Parker, R., Full-scale measurements of impact loads on a large flying boat (Sunderland Mk. 5). IV. Data for impacts on the afterbody, *Aero. Res. Counc. Lond. curr. Pap.* 341, 7 pp. + 2 tables + 16 figs., 1957.

A comprehensive series of landing impact tests has been carried out by M.A.E.E. in both calm and rough water on a Sunderland flying boat.

Results are given in this report for landings in calm water at attitudes where appreciable pressures occur on the afterbody, and comprise data on total forces and local pressures on the afterbody. From author's summary

4223. Parker, R., and Friswell, J. K., Full-scale measurements of impact loads on a large flying boat (Sunderland Mk. 5). V. Results of rough water tests, *Aero. Res. Counc. Lond. curr. Pap.* 342, 10 pp. + 10 tables + 13 figs., 1957.

The results of a number of take-offs and landings in various sea conditions are presented in the form of statistical data, both local pressures and over-all accelerations being given.

During the tests the worst loading conditions were encountered in short to medium swells. From authors' summary

4224. Parker, R., Full-scale measurement of impact loads on a large flying boat (Sunderland Mk. 5). III. Data for impacts on main step, *Aero. Res. Counc. Lond., curr. Pap.* 340, 7 pp. + 2 tables + 16 figs., 1957.

The results of a series of full-scale impact tests on the hull of a Sunderland Mk. 5 flying boat at an all up weight of 50,000 lb were compared with an appropriate theory and discussed generally in a previous report. As discrepancies between the data and the theory were shown and since explanation of this has not been forthcoming, this report presents complete time histories of a number of the actual measurements to permit comparison with other theories when such become available, and application by empirical methods where appropriate.

From author's summary

4225. Haine, M. E., and Jervis, M. W., The design and performance of a new experimental single-transient oscillograph with very high writing speed, *Proc. Inst. electr. Engrs.* (*B*) **104,** 16, 385-392, 1957.

Detailed description of a demountable oscillograph for very rapid transients, having a time resolution of 2×10^{-13} sec per spot width. The demountable construction makes continuous pumping necessary, but permits various types of deflector systems to be used, and allows the current in the final spot to be measured by a Faraday cage moved to intercept the beam. Recording is by direct action of electrons on a photographic plate. Maximum voltage on electron gun is 40 kV; final spot diameter is 20 micron, this being the limiting resolution of the photographic plate to electrons. Electron gun is illustrated and quantitative data given. Deflection chamber is illustrated by sectional drawing, and data of deflector system stated. Electrical circuits are shown (timing and time-base circuits), with quantitative data. Sample oscillograms are shown. Two pages of discussions by other scientists elicited some additional explanations and quantitative data. K. J. DeJuhasz, Germany

4226. Fraser, R. P., and Dombrowski, N., The dependence of interpretation on photographic technique in fluid kinetics research, Proc. Third intern. Congr. on high-speed Photography, Sept. 1956, London, Butterworths Scientific Publications, 376–384.

Study of fast physical processes by high-speed photography often requires more than one method of lighting to obtain the needed information. Moreover, the exposure time may have to be varied from microseconds to centiseconds, with application of double exposure, streak, and interferometric techniques. Authors give illustrations of four different techniques of lighting (diffuse reflection, diffuse transmission, specular reflection, and parallel transmission) and of exposures in the study of disintegration of liquid sheets leaving a spray nozzle.

K. J. DeJuhasz, Germany

4227. Dietrich, W., The "Blauschreiber," a new instrument for recording nonperiodic phenomena (in German), *Nachrichtentechnische Z.* **9,** 11, 504-507, 1956.

A cathode-ray oscillograph has been developed by the C. Lorenz AG. on which the trace is preserved for several days, unless it is extinguished intentionally. This characteristic makes it suitable for recording non-recurring phenomena. The oscillograph has a rectangular mica screen of 8 × 12-cm size; it is coated on its inner surface with a layer of potassium chloride on which the electron ray leaves a blue-violet trace. The trace can be extinguished by illuminating or by heating it, after which it regains its original white-bluish color. The mica screen is coated on its outer side with a transparent conducting layer which can be heated electrically; the extinguishing time is about 10 sec. The electrical circuit is described and the means for timing scale, contrast control, extinguishing, and trace shift are explained. Some sample oscillograms are shown. Significant data: time deflection: 1000, 300, 100, and 10 milliseconds; vertical deflection: 2, 5, 10, 20, 100 V per cm; frequency range: 0 to 15 kilocycles; writing speed: about 400 m/sec, max.; time for extinguishing: variable from a few seconds to several minutes.

K. J. DeJuhasz, Germany

4228. Dombrowski, N., Fraser, R. P., and Peck, G. T., A short-duration, double-flash system for simultaneous or delayed operation, *J. sci. Instrum.* **32,** 329–331, Sept. 1955.

Development of apparatus employing two separate flash-discharge tubes operated either simultaneously or consecutively, with a means for varying the interval from 0.01 to 10 milliseconds. The two sources of energy of 5 J are designed for a flash duration of 6 microseconds at 10 per cent of peak light. Circuit is described and illustrated. Delay circuit is described. Application to study of spray issuing from nozzle is described and illustrated with sample photo.

K. J. DeJuhasz, Germany

4229. Fraser, R. P., High speed photography in fluid kinetics, *J. photographic Sci., Lond.* **3,** 21–32, 1955.

Photographic technique used in laboratories can be of three kinds, according to the manner of illumination: (1) light reflected from object, illuminated by a continuous source, intermittent source, or single flash; (2) light transmitted past or through object to give a shadow; (3) light emitted by self-luminous objects, such as flames or arcs. With each form of illumination the record may be a single photograph, a series, or a continuous graphical record on a moving film in a chronograph camera. Details of these methods are described. Examples taken from the work of author's laboratory are given, with sample photos, from investigations of (a) detonation wave (using schlieren shadow technique), (b) supersonic flow through model nozzles; (c) air discharge through a two-dimensional nozzle with straight sides and with curved sides, (d) formation and projection of liquid jet, (e) disruption of liquid jet in flight, (f) formation of drops from a sheet of liquid of various surface tensions, (g) velocity distribution in a liquid sheet from a fan spray using a double-flash apparatus developed by Ernest Turner (Electrical Instruments) Ltd., High Wycombe, Bucks., England.

K. J. DeJuhasz, Germany

4230. Coulson, J. M., and Dombrowski, N., Photographic studies in chemical engineering research, *J. photographic Sci., Lond.* **3,** 88–94, 1955.

Photography is a useful tool in clearing up the basic mechanism of certain processes in chemical engineering, such as size reduction of solids and liquids, concentration of aqueous solutions by evaporation, separation of liquids by distillation, solution of a gas in liquid by absorption, formation of crystals, formation of liquid drops in air or in another liquid, formation and bursting of bubbles. Instructive pictures of each of these phenomena and some explanation of the photographic method and materials are given.

K. J. DeJuhasz, Germany

4231. Edgerton, H. E., Shock wave photography of large subjects in daylight, *Rev. sci. Instrum.* **29,** 2, 171–172 (Notes), Feb. 1958.

A method of photographing shock waves is described which makes it possible to work on large-scale experiments outdoors in daylight. Formerly, such experiments have been made at night or indoors. From author's summary

4232. Hovell, P. B., and Butler, A. R., Records of static pressure tests on pressure cabins, *Aero. Res. Counc. Lond. curr. Pap.* 376, 3 pp. + 1 table, 1958.

Results of static pressure tests on 20 fuselages are given. The information is primarily for record and further use as required. Brief details of the locations of premature failures are given, and general conclusions are drawn to account for the difference in the results obtained for fighter and transport aircraft.

From authors' summary

4233. Smith, T. L., Special types of internal strain gage balances, *AGARD Rep.* **7,** 11 pp., Feb. 1956.

Thermodynamics

(See also Revs. 3861, 3894, 4105, 4115, 4121, 4192, 4200, 4262, 4269, 4274)

4234. Reik, H. G., The thermodynamics of irreversible processes: Approximation of the Enskog gas theory. I. One component system. II. Multiple component systems (in German), *Z. Phys.* **148,** 2, 156–176; 3, 333–354, 1957.

Prigogine [*Physica* **15,** p. 272, 1949] had investigated the limits of validity of irreversible thermodynamics by studying the Enskog expansion of the Boltzmann equation. Author carries out the detailed analysis of this problem for the case of a gas with internal degrees of freedom. In section II, it is generalized to multi-component systems, including chemical reactions.

L. Tisza, USA

4235. Prigogine, I., and Bingen, R., Statistical mechanics of irreversible phenomena, Part IV (in French), *Physica* **21,** 299–311, 1955.

A study of irreversible processes in linear chains of harmonic oscillators. The theory is applied to three-dimensional crystals. It is shown that the local distribution functions all tend to Gaussian distributions and the crystal to local homogeneity, whatever the initial distribution functions may be.

L. M. Grossman, USA

4236. Brout, R., and Prigogine, I., Statistical mechanics of irreversible processes, Part V. Anharmonic forces, *Physica* **22,** 35–47, 1956.

Paper is a study of the mechanism by which the amplitudes of the normal modes of a crystal tend asymptotically to the canonical (Gaussian) distribution, in a network subject to small anharmonic forces. A statistical ensemble of like systems is considered and the amplitudes are treated as independent stochastic variables.

L. M. Grossman, USA

4237. Brout, R., and Prigogine, I., Statistical mechanics of irreversible processes, Part VI. Thermal conductivity of crystals, *Physica* **22,** 263–272, 1956.

A theory for the thermal conductivity of crystals is developed based upon authors' theory of the evolution in time toward the equilibrium distribution of a crystal subject to slightly anharmonic forces.

L. M. Grossman, USA

4238. Brout, R., Statistical mechanics of irreversible processes, Part VII. Boltzmann equation, *Physica* **22,** 509–524, 1956.

Author investigates the conditions under which an irreversible transport equation in the velocity space for N molecules for macroscopically homogeneous systems (called the "master equation" by Kac and Uhlenbeck) reduces to the Boltzmann equation.

L. M. Grossman, USA

4239. Brout, R., and Prigogine, I., Statistical mechanics of irreversible processes, Part VIII. General theory of weakly coupled systems, *Physica* **22,** 621–636, 1956.

Authors discuss the classical statistical mechanics of irreversible processes in weakly coupled multiply periodic systems in terms of the spectral decomposition of the density distribution in phase space.

L. M. Grossman, USA

4240. Curl, R. F., Jr., and Pitzer, K. S., Volumetric and thermodynamic properties of fluids—enthalpy, free energy, and entropy, *Indust. Engng. Chem.* **50,** 2, 265–274, Feb. 1958.

New methods for calculating enthalpy, entropy, fugacity and critical constants (temperature, pressure, and volume) of normal fluids are presented. The criterion of a normal fluid is a dimensionless parameter ($\sigma_0 V_0^{2/3}/T_c$), where σ_0 is a hypothetical surface tension at 0°K, V_0 is the molal volume at 0°K, and T_c is the critical temperature. Methods for evaluating the needed surface tension and molal volume are included. The method for calculating enthalpy, entropy and fugacity is rapid and simple. It involves a calculation of the so-called acentric factor and a subsequent reference to tables presented. The physical data needed for calculating the acentric factor are the critical temperature and the vapor pressure at a reduced temperature of 0.7.

The estimation of critical constants is based on Riedel's method [*Chem.-Ing. Tech.* **27,** p. 475, 1955] and involves a set of converging approximations. Data for this type of calculation are presented.

There are several typographical errors; two of a family of curves (in Figure 5) are mislabelled, also, an example is solved in which the molecular weight of 93 is used for toluene.

M. L. Baker, USA

4241. Moeckel, W. E., and Weston, K. C., Composition and thermodynamic properties of air in chemical equilibrium, *NACA TN* 4265, 4 pp. + 5 figs., Apr. 1958.

Charts have been prepared relating the thermodynamic properties of air in chemical equilibrium for temperatures to 15,000 K and for pressures from 10^{-8} to 10^{+4} atmospheres. Also included are charts showing the composition of air, the isentropic exponent, and the speed of sound. These charts are based on thermodynamic data calculated by the National Bureau of Standards.

From authors' summary

4242. Baldwin, L. V., and Blackshear, P. L., Preliminary survey of propulsion using chemical energy stored in the upper atmosphere, *NACA TN* 4267, 54 pp. + 5 tables + 12 figs., May 1958.

Ramjet cycles that use the chemical energy of dissociated oxygen for propulsion in the ionosphere are presented. After a review of the properties and compositions of the upper atmosphere, the external drag, recombination kinetics, and aerodynamic-heating problems of an orbiting ramjet are analyzed. The study indicates that the recombination ramjet might be useful for sustaining a satellite at an altitude of about 60 miles. Atmospheric compo-

sition and recombination-rate coefficients were too uncertain for more definite conclusions. The ramjet is a marginal device even in the optimistic view. From authors' summary

4243. Gin, W., Calculated viscosity of a solid propellant rocket exhaust gas mixture, *Jet Propulsion* **28,** 2, 127–128, Feb. 1958.

The absolute viscosity of the exhaust gas mixture from the rocket combustion of a composite-type solid propellant has been calculated according to rigorous kinetic theory. Seven species including trace concentrations were considered, and the temperature of the mixture was taken to be 2160 R. The computed value of the viscosity is 9.76 (10^{-7}) lb-sec/ft^2, which is shown to be approximated well by a value obtained from less rigorous theory.
From author's summary

4244. Gasparovic, N., Gas turbines with added steam before and after the combustion chamber (in German), *Forsch. Geb. Ing.-Wes.* **23,** 5, 176–182, 1957.

The influence of adding saturated or superheated steam to the gas turbine process on the efficiency, the air flow rate, the exhaust gas temperature, etc., can be quickly evaluated and distinctly plotted when introducing simplifying assumptions. The investigation comprises plants without and with air preheating. Adding steam results in the advantages of an improved efficiency and of a deceased air flow rate; however, the disadvantages of a higher prime cost of the plant due to the steam generator and of the costs for the necessary cleaning of the water have to be taken into account. Economical considerations may depend mainly on the water-cleaning costs. From author's summary

4245. Saboe, M. S., Developing an aircraft gas turbine, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-143, 4 pp.

4246. Jacobs, D. L. E., and Landes, I. H., Equipment for the stationary gas turbine, *Mech. Engng.* **80,** 7, 45–51, July 1958.

4247. Bruce, D. F., Gas turbines for process applications, *Mech. Engng.* **80,** 3, 75–78, Mar. 1958.

4248. Angelo, J., and Cotton, K. C., Observed effects of deposits on steam turbine efficiency, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-116, 14 pp.

Heat and Mass Transfer

(See also Revs. 3861, 3872, 3894, 3919, 3921, 3922, 3923, 3924, 3984, 4042, 4109, 4115, 4147, 4155, 4186, 4216, 4240, 4275, 4276, 4277, 4279)

4249. Friedmann, N. E., Quasilinear heat flow, *Trans. ASME* **80,** 3, 635–645, Apr. 1958.

The object of the study was to present results showing the effect of changes in thermal conductivity, density, and heat capacity with temperature on the solutions of the heat-conduction equation. Results were obtained both by analog computation and analytically for several finite and semi-infinite solids. The systems studied are characterized by simple boundary and initial conditions. The property changes with temperature covered linear and power-function variations. The effect of property changes on computed temperatures were found to be significant. This is an important reference for those engaged in the solution of problems involving property variation with temperature.
G. A. Hawkins, USA

4250. Dean, L. E., and Shurley, L. A., Analysis of regenerative cooling in rocket thrust chambers, *Jet Propulsion* **28,** 2, 104–110, Feb. 1958.

Realistic determination of heat flux and temperature distribution within the walls of a rocket thrust chamber requires experimental and empirical techniques. Conjoining experimentally determined heat-transfer data on JP-4 and RFNA, yielding liquid film heat-transfer coefficients as occur in practice, with analog simulation, effected by use of conductive paper and associated auxiliaries in well-known fashion, yields two-dimensional plots of heat-flux and temperature distribution within the walls of a tubular chamber cooled with JP-4 and within the walls of a drilled-passage thrust chamber cooled with RFNA. Determination of the transfer coefficients and construction and use of the analog apparatus are given in detail. This well-written paper will be of interest to all concerned with rocket-engine design or electroanalogic measurement. T. J. Higgins, USA

4251. Penrod, E. B., Walton, W. W., and Terrell, D. V., A method to describe soil temperature variation, *Proc. Amer. Soc. civ. Engrs.* **84,** SM 1 (*J. Soil Mech. Div.*), Pap. 1537, 22 pp., Feb. 1958.

Equation is given for calculating monthly variation of soil temperature at various depths. Observed data are used to determine the equation constants for the particular soils involved. Agreement with actual measurements at different localities is reasonable. Precipitation is accounted for only indirectly through determination of constants from measured soil temperatures. No method is given for finding the numerical value of constants from primary climatic factors such as dry-bulb temperature, solar radiation, etc. A. Whillier, South Africa

4252. Hucks, J. S., and Gaines, A. L., An analytical method of predicting temperature gradients in thick-walled pressure vessels, ASME Ann. Meet., New York, N. Y., Dec. 1957, Pap. 57-A-231, 5 pp.

Analytical methods for determining the thermal gradients in a thick-walled pressure vessel due to a linear temperature change on the inner surface were determined and found to be verified experimentally. The analytical method was found to predict accurately the thermal gradients in uniform sections; and an empirical relation, the gradients at a discontinuity of sections. A discussion is included on the methods, boundary-condition assumptions, and physical constants, as used in the analytical approach to the transient-conduction heat-flow problem.
From authors' summary by Y. S. Touloukian, USA

4253. Reilly, P. M., Unsteady state heat transfer in stationary packed beds, *AIChE J.* **3,** 4, 513–516, Dec. 1957.

Paper describes the transient temperature distribution for one-dimensional flow of a fluid through a stationary packed bed of finite length. Both an arbitrary initial temperature distribution within the bed and an entrant fluid temperature which varies arbitrarily with time are included in the solutions. Using a finite range, i.e., the bed length, author expands the solution in terms of a Fourier series, and, by extending the entrant fluid temperature spacewise to negative infinity and the exit fluid temperature spacewise to positive infinity, he obtains a second solution, expressed in terms of Fourier integrals. A calculated regeneration solution is included for illustration. E. V. Somers, USA

4254. Pagni, M., On a typical boundary value heat equation problem (In Italian), *Ann. Scu. norm. sup. Pisa,* Series III, **11,** 1/2, 73–155, June/July, 1957.

Author occupies himself with the very general boundary problem for the heat equation:

$$\frac{\partial^2 u}{\partial x_1^2} + \frac{\partial^2 u}{\partial x_2^2} - \frac{\partial u}{\partial y} = f \text{ (in } \tau - \sigma, \sigma = \text{boundary)}$$

$$u = \varphi \text{ on } D, \left(\frac{\partial u}{\partial l}\right) = g \text{ on } S;$$

r is a cylindrical space of D base on lateral surface S, $\frac{\partial u}{\partial l}$ is the derivative (on S), along the oblique regular asis l, and the functions l and g are dependent on the variables x_1, x_2 and y.

The existence of a "faint" solution of the problem is demonstrated; but the author demonstrates that this solution is also a "strong" solution of the problem. A. Pignedoli, Italy

4255. Friedmann, N. E., The truncation error in a semi-discrete analog of the heat equation, J. Math. Phys. 35, 3, 299–308, Oct. 1956.

Author considers the problem of obtaining an estimate of the difference between an exact solution of the heat equation in a finite solid and an exact solution of a semi-discrete analog replacing the same problem. From author's summary

4256. Caricato, G., On stationary heat transfer through a homogeneous wall bounded by two eccentric spheres (in Italian), *R. C. Mat. Appl.* (5) **16,** 1/2, 131–139, Jan.–June 1957.

Application of a general theorem by A. Signorini [*Abb. Math. Sem., Univ. Hamburg* (21), 1/2, pp. 78–86] on the upper and lower bounds of the heat transmitted through a wall, if the temperatures of the media on both sides of the wall are uniform. Using the orthogonal trajectories of the bundle of spheres determined by the inner and outer boundary as coordinate lines, author deduces explicit expressions for the upper and lower bound of the heat quantity. Neglecting second- and higher-order terms in the case of small eccentricities, both bounds converge to the same value, which corresponds to the heat quantity transmitted between two concentric spheres. A. Kuhelj, Yugoslavia

4257. Fay, J. A., and Riddell, F. R., Theory of stagnation point heat transfer in dissociated air, *J. aero. Sci.* **25,** 2, 73–85, Feb. 1958.

Paper extends the laminar boundary-layer equations in a dissociated gas in the fashion of Moore [AMR **6** (1953), Rev. 1339] with the improvements of Lees [AMR **9** (1956), Rev. 3390] by including the thermal diffusion coefficients, which are subsequently neglected in the numerical part. The partial differential equations can be converted to ordinary differential form by suitable transformations for the cases of a flat plate, a cone and the stagnation point, and this analysis of the stagnation point on a hemisphere is justified by the impracticability of maintaining a sharp nose with these rates of heat transfer. The two extremes of recombination rate give rise to simple solutions of the general case and these are considered in detail in the early part of the paper. A recombination rate parameter is then introduced to cover intermediate cases. This parameter is the ratio of the diffusion time to the lifetime of an atom and as such introduces the nose radius. Another scale effect is thus introduced which requires satisfaction, in addition to the Reynolds number. The main derivation in the heat transfer from the low temperature perfect gas value is due to the variation of $\rho\mu$ across the layer, the value at the outside of the layer having greatest effect. Probably the most interesting part of the paper is the study of the catalyticity of the wall. If the wall is catalytic, the total heat transfer is little affected by a nonequilibrium state in the layer, but if the recombination rate is low, the heat transfer may be greatly reduced by the use of a non-catalytic wall.

T. V. Lawson, England

4258. Rose, P. H., and Stark, W. I., Stagnation point heat-transfer measurements in dissociated air, *J. aero. Sci.* **25,** 2, 86–97, Feb. 1958.

An experimental program to compare with the theory of Fay and Riddell [see preceding review]. Methods of hypersonic research are reviewed and the choice of the shock tube justified: straight shock tubes are used throughout, except for a few readings from a hypersonic shock tunnel. Excellent detailed descriptions of the main instruments, a resistance thermometer and a calorimeter gauge, are given, but reviewer believes more trouble can be experienced in the behavior of the soldered joint than is described.

The results show good agreement with the theory; and given the premise that the conditions in the region around the stagnation point are unaffected by Mach number, the paper leaves little to discuss, except to regret that not more information was given concerning the measurement of the shock Mach number. Shock-wave attenuation is discussed, so it is presumed that the Mach number in the working section was not measured; and especially if the tube was combustion driven, errors are possible, errors which, though small when considering shock Mach number, can be appreciable, especially at the lower end, when converted to heat transfer due to the logarithmic variation between the two.

T. V. Lawson, England

4259. Van der Hegge Zijnen, B. G., Heat transfer from horizontal cylinders to a turbulent air flow, *Appl. sci. Res.* (*A*) **7,** 2/3, 205–223, 1958.

This is an attempt to rationalize the influence of free-stream turbulence on heat loss from circular cylinders on the basis of extensive new data covering wide ranges of (a) cylinder Reynolds number, (b) free-stream turbulence level, (c) ratio of turbulence integral scale to cylinder diameter.

The semi-empirical approach seems reasonably successful, although only qualitative reference is made to the actual fluid dynamical phenomena possibly involved. Perhaps the most interesting result is that, for fixed Reynolds number (in the range from 2000–25,800) and turbulence level, there is an optimum scale-to-diameter ratio for maximizing the Nusselt number.

S. Corrsin, USA

4260. Pridmore Brown, B. N., Heat transfer in a laminar boundary layer from a surface having a temperature distribution, *J. aero. Sci.* **24,** 12, 912–913 (Readers' Forum), Dec. 1957.

Heat-transfer and pressure measurements were made in a laminar boundary layer generated on the outer surface of an unchoked hollow cylinder aligned axially with a Mach 2.5 flow.

From author's summary

4261. Helve, J. H., Steady-state thermal design of pressurized light-water cooled and moderated nuclear reactor cores, ASME Ann. Meet., New York, N. Y., Dec. 1957, Pap. 57-A-219, 38 pp.

Paper gives a qualitative description and summary outline of the steps employed in the steady-state thermal design of a power reactor. Some of the design criteria are stated. Typical "hot channel" factors are listed for a core with flat-type fuel elements and non-boiling coolant, also the burn-out heat velocity relations adopted at KAPL. Present practice in light-water cooled reactors is given as prohibition of any type of boiling in the core during steady-state operation and normal maneuvering, and of bulk boiling during transients. C. F. Bonilla, USA

4262. Clark, L. G., and Hagerty, W. W., Thermal resistance of an eddy, *AIChE J.* **3,** 4, 523–527, Dec. 1957.

A stationary vortex is produced in the plane of rotation between concentric rotating cylinders. The angular momentum of the vortex is calculated from photographs of the motion of entrained aluminum particles. Velocity corrections are applied for curvature of the cylinders. A linear relation is shown between angular momentum of the vortex and rotational speed of the cylinder. The relationship between heat transfer of the vortex alone and rotational speed is then obtained, heating the inner cylinder and computing losses due to the cylinder walls, end effects, and coolant. This relationship is approximately linear above the critical speed for formation of the vortex. Finally, a linear dependence of heat-

transfer coefficient on angular momentum of the vortex is shown, within the limits of a rather appreciable experimental error.

H. M. Spivack, USA

4263. Guha, C. R., and Yih, C.-S., Laminar convection of heat from two-dimensional bodies with variable wall temperatures, Proc. Fifth Midwest. Conf. Fluid Mech., Apr. 1957, 29–40.

By using the velocity distribution obtained from the Blasius-Howarth expansion for the boundary layer on an arbitrarily shaped two-dimensional body, a series of functions has been obtained from which the temperature in the boundary layer can be determined once the wall temperature (which is assumed to be variable) is specified. Steady state is considered and Frossling's approach is used. From authors' summary by T. J. Connolly, USA

4264. Jack, J. R., and Diaconis, N. S., Heat-transfer measurements on two bodies of revolution at a Mach number of 3.12, *NACA TN* 3776, 36 pp., Oct. 1956.

Experimental heat-transfer data from a cone-cylinder and a parabolic-nosed cylinder at $M = 3.12$ are correlated by Stanton number versus Reynolds number. Bodies were initially heated or cooled, and local film coefficients determined by transient temperature gradients, conduction, and radiation are included. Maximum free-stream Reynolds number was 12×10^6.

Results in the laminar regime agree well with theory when corrected for surface temperature gradients. Turbulent results from heated cone show fair agreement with the theory of Van Driest.

Some graphs have temperature-gradient correction, others do not. No indication of this important factor is shown on the graphs.

This report typifies the confused state of heat-transfer literature. At least six references must be consulted to interpret the basic procedures. G. M. Ketchum, USA

4265. Ede, A. J., Hislop, C. I., and Morris, R., Effect on the local heat-transfer coefficient in a pipe of an abrupt disturbance of the fluid flow: abrupt convergence and divergence of diameter ratio 2/1, *Instn. mech. Engrs. Proc.* **170,** 38, 1113–1130, 1956.

This reviewer believes that an error in sign exists in the equation presented for the temperature of the inner surface of the pipe in the authors' discussion of experimental technique. It appears that the algebraic sign preceding the final term should be positive. The assumption of uniform current density upon which this equation is based, in part, should be recognized as the limiting case, where radial thermal gradients are small. The authors found that abrupt divergence markedly affects the local heat-transfer coefficient, increasing it three to four times the limiting value, the effect noticeable for about 20 diameters. Abrupt convergence results in only about a 20% increase in this coefficient, the effect becoming negligible after six diameters. The range of Reynolds numbers for the abrupt divergence was 3700–45,000 in 2-inch pipe and 800–100,000 for abrupt convergence in 1-inch pipe.

C. R. Mischke, USA

4266. Matsunaga, S., On radiation from combustion gas, *Jet Propulsion* **28,** 2, p. 125, Feb. 1958.

4267. Sugawara, S., Michiyoshi, I., and Minamiyama, T., The condensation of vapour flowing normal to a horizontal pipe, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. Kyoto, Japan, Oct. 1956, 385–388.

Filmwise-condensation heat transfer with vapor flowing normal to a single horizontal pipe is analyzed mathematically. Only the specific physical situation of vertical flow of vapor toward the top of the cylinder is covered. The effect of vapor velocity on heat-transfer rates is included in the analysis. Simplifying assumptions are made, such as: negligible vapor-side resistance, linear radial temperature distribution in condensate film, and constant fluid properties. Expressions for both local and average heat-transfer coefficients are given, and the results are shown graphically. D. M. Mason, USA

4268. Albertson, M. L., Mechanics of evaporation, Chaps. V, VI, VII (in English & French), *Houille blanche* **11,** 2, 282–311, May/June 1956.

Review of former literature on heat and mass transfer (evaporation in particular) and the applicability of Reynolds analogy to it; designing and carrying out laboratory experiments to determine the applicability of Reynolds' analogy to the problems of evaporation; determining the extent of applicability of other equations to express evaporation under natural conditions; reproducibility in a model of wind structure actually existing in nature; determining the extent to which model studies of evaporation can be utilized for predicting evaporation under natural conditions. Subjects discussed: definition of evaporation; concept of boundary layer and its connection with diffusion; diffusion theory: molecular diffusion corresponding to laminar flow, and molar diffusion corresponding to turbulent flow; Dalton's law; theories on energy distribution and of mass transfer; convection and its free, laminar, and turbulent forms; Reynolds analogy and its extension by Taylor, Prandtl, von Karman, Hoffmann, and others; empirical equations for mixing and evaporation; Sutton's theoretical evaporation equation; experimental investigation of evaporation in wind tunnel at Colorado A and M College; calculation of shear velocity.

K. J. DeJuhasz, Germany

4269. Heidmann, M. F., and Priem, R. J., Propellant vaporization as a criterion for rocket engine design; relation between percentage of propellant vaporized and engine performance, *NACA TN* 4219, 7 pp. + 8 figs., Mar. 1958.

A method is presented for evaluating experimental rocket-engine performance in terms of the percentage of liquid propellant vaporized. The method is based on a hypothesis that rocket performance is limited by the rate of vaporization of the propellants. An expression relating characteristic exhaust velocity to the percentages of oxidant and fuel vaporized and burned is given. The analysis is applied to the hydrogen-fluorine, hydrogen-oxygen, ammonia-fluorine, and JP-4-oxygen propellant combinations.

From authors' summary

4270. Matsunaga, S., On the thermal resistance of the water droplet on the metallic surface, *Jet Propulsion*, **28,** 2, p. 126, Feb. 1958.

4271. Shiba, K., and Ueda, M., Humidity distribution and rate of evaporation of water, Proc. Sixth Japan. nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 373–376.

Combustion

(See also Revs. 4105, 4162, 4244, 4266)

4272. Berl, W. G., Gayhart, E. L., Maier, E., Olsen, H. L., and Renich, W. T., Determining of burning velocity of pentaborane-oxygen-nitrogen mixtures, *Combustion and Flame* **1,** 4, 420–430, Dec. 1957.

Pentaborane has been selected as a representative boron hydride in order to obtain burning velocity measurements over a wide range of fuel-air mixtures. Freely propagating laminar flame kernels produced by spark ignition are photographed by the flash schlieren technique, and the burning velocity is derived from the measured rate of growth of these kernels. The pentaborane-air burning velocity reaches a maximum value slightly on the rich

side of stoichiometric. The influence of oxygen concentration on burning velocity is reported. Pentaborane flames show pronounced cellular structure of the flame front at all mixture ratios.

From authors' summary

4273. Miele, A., An extension of the theory of the optimum burning program for the level flight of a rocket-powered aircraft, *J. aero. Sci.* **24,** 12, 874-884, Dec. 1957.

Paper is another in a series by same author on optimum burning programs using methods of calculus of variations. General theory optimizes (relative to a given kind of performance) both flight path geometry and engine mode of operation; present paper assumes path given and optimizes engine operation. The problem: "A rocket engine, capable of delivering a variable thrust, is applied to a vehicle of given configuration moving along a straight, horizontal path. The initial time instant (t_i), mass (m_i), abscissa (X_i), and velocity (V_i) are prescribed; some, but not all, of the final coordinates t_f, m_f, X_f, V_f are given. It is required to determine the thrust-programming technique which minimizes a specified, though arbitrary, function G_f (t_f, m_f, X_f, V_f) of the coordinates of the final point." Some special cases: maximum range, given propellant mass and final velocity (free time); maximum endurance, given same (free distance); minimum propellant consumption, given range and final velocity (free time); maximum final velocity, given propellant mass and range (free time); and similar, including analysis of maximum range problem where time is prescribed (relatively more difficult).

R. E. Roberson, USA

4274. Reichert, H., Enthalpy charts: for dissociating gas mixtures in the temperature range 600 deg to 4000 deg K, *Aero. Res. Counc. Lond. Rep. Mem.* 3015, 16 pp. + 4 tables + 2 figs., 1957.

Twenty enthalpy versus oxygen-content charts have been prepared for C-H-O systems having atomic C/H ratios of 0, 0.2, 0.4, 0.6, and 0.8, and at pressures of 0.1, 1.0, 10.0, and 100.0 kg/sq cm. The enthalpy includes chemical enthalpy and is defined relative to the elements in their standard states. Families of curves of constant temperature, of constant entropy, and of constant mean molecular weight are plotted on each chart. Formulas for extending the charts for mixtures containing nitrogen are presented. Only four charts are included (for C/H = 0.4), the other 16 being available on request. All pertinent equilibria were considered in preparing the charts; however, the value used for heat of sublimation of graphite is now known to be incorrect. Examples of applications of the charts are presented.

R. Friedman, USA

4275. Cotte, M., Cooling of a cylinder leaving a furnace with a constant velocity (in French), *Chaleur et Industrie* **38,** 384, 187-193, July 1957.

In the first part of the paper, cooling of a homogeneous metallic cylinder, leaving a furnace (temperature of which is T_0) with a constant velocity **v**, is considered. Temperature of the cooling medium is θ_0. The cylinder is considered infinitely long; the shell of the furnace infinitely thin. Differential equation with boundary conditions is written. Solution is found in the form of an infinite series (Fourier method, using Bessel's functions. For detailed calculation the reader is referred to author's work in *J. Physique* 1956). The result is discussed and tables and graphs are drawn for some particular values of the parameters.

In the second part, influence of the breadth of the shell of the furnace is considered. In the third part, the problem is complicated by the assumption that the cylinder is not homogeneous, but the inner metallic cylinder is surrounded by a cylindrical layer ("manchon" in French) of a poorer conductor. For detailed calculation reader should again refer to *J. Physique.*

In a supplement the author shows how to solve the problems numerically by use of relaxation method.

K. Rektorys, Czechoslovakia

4276. Tailby, S. R., and Ashton, M. D., Heat transfer from town gas flames to water jacketed horizontal tubes, *Trans. Inst. chem. Engrs.* **36,** 1, 1-12, 1958.

A system in which town gas burns in a horizontal water-cooled tube terminating in a vertical flue is the basis of horizontal gas-fired water boilers. The apparatus used consisted of a water-cooled tube, 12 ft long and 3-in. diam, with a gas burner firing into one end and a 7-ft vertical flue mounted on the opposite end. The tube was constructed so that the heat-transfer rate could be determined for each foot along the length of the tube. Variables investigated were primary-air to gas ratio, gas burner characteristics, entrained excess air, and tube length. The effect of heat input was also investigated. Data given show the effect of the variables on thermal efficiency, local heat-transfer rates along the tube, radiation, and flame length. Radiation measurements were made to study the flame properties. It was found that the effect of altering heat input was highly significant but the other variables seldom had an effect on the system other than the effects resulting from the accompanying change in heat input.

R. G. Nevins, USA

4277. Clark, T. P., Studies of OH, CH, AND C_2 radiation from laminar and turbulent propane-air and ethylene-air flames, *NACA TN* 4266, 13 pp. + 10 figs., June 1958.

OH, CO, CH, and C_2 radiations from propane-air and ethylene-air flames were isolated with a monochromator, and the variation of emitter intensity with equivalence ratio was determined. The ratio of C_2 and CH radiation intensities was found to be a good index of the equivalence ratio in the flame. Turbulent open flames burning on tubes were found to become leaner near the base, but appeared to be burning at the metered equivalence ratio in the turbulent brush. The amount of radiation given off by the flame per unit rate of fuel consumption decreased with increasing average gas-flow velocities and Reynolds numbers, but this decrease could not be accounted for by admixing of the secondary air with the turbulent flame brush.

From author's summary

4278. Maklakov, A. I., Oscillation of diffusion flames appearing when there is a laminar flow of the ignitable medium (in Russian), *Zh. fiz. Khimii* **30,** 3, p. 708, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1572.

Investigations were carried out of flame oscillations for a number of inflammable gases and also of the vapor of such liquids as benzene, kerosene and others, at a determined limit of velocity of flow; these oscillations were periodic for small fuel consumption and aperiodic for large consumption. The velocity limit depends on the diameter, the material used in construction and position of the burner, and also on the nature of the inflammable mixture, but does not depend on the length of the burner. The frequency of the periodic oscillations is equal to 10-15 hert and is almost independent of the nature of the gas and its consumption, but decreases somewhat with increase in the diameter of the burner. At velocities lower than the limit it is possible to arouse periodic oscillations with the aid of a concentric flow of N_2 or CO_2. A qualitative explanation is furnished for the cause of the oscillation phenomenon.

N. N. Bakhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4279. Mullaney, G. J., Temperature determination in flames by x-ray absorption using a radioactive source, *Rev. sci. Instrum.* **29,** 2, 87-91, Feb. 1958.

A radioactive source Fe^{55} was used to measure the density of high-temperature combustion products through a flame zone 6.5 cm long. Premixed propane-oxygen and argon were used for the experiments with a porous metal burner. Temperatures were determined downstream of the main reaction zone in the flame at one atmosphere. Temperature profiles were obtained through the preheat and main reaction zone using radioactive Fe^{55} coated on a small platinum wire as a line source.

From author's summary

Acoustics

4280. Mawardi, O. K., Aero-thermoacoustics (The generation of sound by turbulence and by heat processes), Phys. Soc., Lond., Reports on Progress in Physics, **19**, 1956, 156–187.

Author presents a critical review of title field. First part of paper deals with generation of sound from turbulence in jets and in boundary layers, and with scattering of sound by turbulence. Second part treats heat-maintained vibrations, such as Rijke phenomenon and flame-driven oscillations. Physical ideas are clearly presented, but analytical treatments are brief and for full understanding original papers will have to be consulted.

G. H. Markstein, USA

4281. Biot, M. A., Reflection on a rough surface from an acoustic point source, *J. acoust. Soc. Amer.* **29**, 11, 1193–1200, Nov. 1957.

It is assumed in this simple solution that the roughness of the surface is represented by distributed hemispherical bosses whose size and mutual distance are small relative to wave length. The effect of roughness is then equivalent to a boundary condition for the wave equation, which embodies the surface polarization and the mutual interaction of the bosses. The case of vanishingly small roughness is discussed along with the field intensity at large distance and grazing incidence, and the effect of fluid viscosity is also evaluated. Reference is made to research at Cornell Aeronautical Laboratory and to V. Twersky.

J. J. Polivka, USA

4282. Roumieu, Ch., Acoustics in a nonuniform atmosphere (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3**, 5–9.

Assuming sound velocity square proportional to altitude, second approximation to wave surfaces from a fixed point are spheres whose centers are lower than the point. Envelope of these spheres in the case of a moving point gives the ballistic wave. It is determined for horizontal and vertical uniformly moving point.

G. Moretti, Argentina

4283. Newhouse, A., Applications of the Monte Carlo method to architectural acoustics, *J. acoust. Soc. Amer.* **30**, 1, 1–3, Jan. 1958.

The Monte Carlo method of numerical analysis is applied to the determination of mean free paths and acoustic weighting factors relating probability of collision with walls in rectangular parallelopipeds. The method of calculation is discussed and its extension to determination of reverberation times in coupled rooms and auditoria is evaluated. Tables of relative wall collision probabilities are given for rectangular parallelopipeds of various proportions.

From author's summary

4284. Franklin, R. E., Noise measurements on cold jets using convergent-divergent nozzles, *Aero. Quart.* **8**, 4, 346–359, Nov. 1957.

Tests have been carried out on a series of convergent-divergent nozzles and the results compared with those from a test on a convergent nozzle. At the design pressure ratio, reductions in the noise were found, particularly at 90° to the jet direction. For lower forward pressures the noise is also less, but above the design pressure the noise rises rapidly to the same level as that with a convergent nozzle. In the experiments cold jets were used, but the results are probably applicable in certain respects to hot jets.

From author's summary

4285. Callaghan, E. E., and Coles, W. D., Far noise field of air jets and jet engines, *NACA Rep.* 1329, 15 pp. + 32 figs., 1957.

The effect of nozzle-exit shape was studied using a small (4-in. diam) air jet. Circular, square, rectangular, and elliptical convergent nozzles and convergent-divergent and plug nozzles were investigated. At low jet pressure ratios (less than 2.2) the effect of nozzle shape on the sound field was negligible. At high jet pressure ratios all the nozzles exhibited discrete-frequency noises associated with shock formations in the jet. The convergent-divergent nozzle showed an elimination of such noises at its design pressure ratio. The acoustic power radiated by the engines and air jet was correlated by the Lighthill parameter. The free-field spectral distribution of the sound power was in good agreement for both engine and air jet.

From authors' summary

4286. Ciepluch, C. C., North, W. J., Coles, W. D., and Antl, R. J., Acoustic, thrust, and drag characteristics of several full-scale noise suppressors for turbojet engines, *NACA TN* 4261, 19 pp. + 20 figs., Apr. 1958.

An experimental investigation was conducted with an engine in the 10,000-pound-thrust class. The acoustic study was made with an outdoor thrust stand. Acoustic data are presented in terms of sound directionality, spectrum, and sound power. Aerodynamic properties of the suppressors were evaluated over a range of Mach numbers up to 0.5 in an altitude wind tunnel. The most efficient configurations from both acoustic and propulsive thrust considerations were a two-position mixing nozzle with ejector and a 12-lobe nozzle. At a Mach number of 0.5 the respective propulsive thrust losses were about 1 and 3%. Calculations indicate that these two configurations would reduce the noise heard during takeoff by 5 or 6 decibels.

From authors' summary

Ballistics, Detonics (Explosions)

(See Rev. 4116)

Soil Mechanics, Seepage

(See Revs. 4251, 4297)

Micromeritics

(See also Revs. 3861, 3871, 3920, 4083)

4287. Fraser, R. P., Eisenklam, P., and Dombrowski, N., Liquid atomization in chemical engineering, Reprinted from *Brit. chem. Engng., London* **2**, Aug., Sept., Oct., Nov. 1957. 23 pp.

After a concise survey of the broad fields of application of sprayed liquids in combustion, agriculture and chemical engineering and the wide range of physical properties of liquids to be atomized, authors present a classification of atomizers, and discuss the mechanism of disintegration, spray sheet development, expansion of liquid surfaces, drop sizes from atomizers, and effect of ambient conditions. Detailed treatment is accorded to three main groups of atomizers: (a) Rotary (liquid flow equations and relationships, processes of drop formation, drop sizes, and drop penetration); (b) pressure nozzles (classification into subgroups of single-

orifice, impinging-jet, deflector-nozzle, and swirl types, energy requirements and efficiency of atomization, performance, discharge coefficient, size of spray sheets, drop-size, and spatial dispersion); (c) twin-fluid atomizers (process of drop formation, drop size relationships with different viscosities, and energy utilization). The types of nozzles are illustrated in clear cross-sectional drawings, and the relationships are given by equations and in charts. K. J. DeJuhasz, Germany

4288. Eutenauer, G. A., Drop size and throw distance of jet sprays as functions of pressure (in German), *VFDB-Zeitschrift* **6,** 3, 124–128 + 9 figs., Aug. 1957.

Experience has shown that the increase of the throwing distance of a broken up liquid jet will reach a limit beyond which an increase of pressure does not result in increased throwing distance; in fact, in the case of wide-angle conical jets increasing pressure may decrease the throwing distance. These effects have been investigated from the aspect of fire fighting. Drop size, throwing distance, air resistance, rate of discharge, etc., depend on the pressure. These values and the nozzle design influence the efficiency of discharge. Equations have been derived based on simplifying assumptions, which are also represented graphically, showing the maximum throwing distance as a function of pressure, nozzle diameter, and shape of spray (large and small cone angle). These show a qualitative agreement with experimental results.
K. J. DeJuhasz, Germany

4289. Electronic counter combines speed and reproducibility in measuring size-distribution of fine particles, *Chem. Engng. News* **35,** 24, p. 92, June 17, 1957.

Instrument is based on following principle: The suspension flows through a nozzle between two electrodes; when a particle passes through it affects the electric resistance proportionately to the particle size. The electrical impulses are amplified, classified, and counted. In 15 seconds about 0.5 cc flows through the nozzle, containing about 10,000 to 100,000 particles. The ratio of conductivity of the particle and the liquid must exceed 2 or 3. For size-distribution determination, calibrating experiments must be made. Instrument can be adapted for particles between 1.0 to 150 microns by varying the nozzle diameter. Instrument was developed for counting blood corpuscles. Applicability to other dispersoids is questionable because of the unknown influence of the irregular shape of the particles. K. J. DeJuhasz, Germany

4290. Levsh, I. P., Niyazov, M. I., and Erofeeva, O. B., Some problems of hydrodynamics of a suspended layer (in Russian), *Trudi Sredneaz. politekhn. in-ta, Tashkent, Gosizdat UzSSR,* 1955, 298–305; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2091.

The experimental investigation of the hydrodynamic resistance of a suspended layer was carried out in a glass tube with inner diameter of 31.4 mm. The experiments were made with quartz sand with particles measuring from 0.75 to 1.00 mm. Basic interest was concentrated on ascertaining the influence of the hydrodynamic resistance of the sieves supporting the sand on the resistance of the layer. Five different (types of) sieves were tested, each time with a different loading of sand. Results are given of the calculation of a live section of the flow and porosity for a number of tests. The measured amplitudes of resistance for different experiments are recorded in curves. A degree of relationship between the resistance and the shape of the sieve was established.
E. M. Minskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4291. Charnov, A. P., The coefficient of resistance of solid particles in gaseous suspension (in Russian), *Izv. Akad. Nauk Otd. tekh. Nauk* no. 11, 135–138, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2092.

Attention is drawn to the deficiencies in G. N. Khudyakov's article dealing with the determination of the dependence of the coefficient of resistance of fine particles on Reynolds number R. In the course of working out the results of the experimental data material mistakes were made; in consequence the formula put forward by Khudyakov for calculating the coefficient of particle resistance in relation to criterion R, $C = 1.4R^{-0.18}$ [1], appears to be incorrect. The author's own calculations made with the same experimental data gave the following correlations, connecting the coefficient of resistance of the particle and the coefficient of resistance of the equivalent sphere, $C = \xi C_{sph}$ [2], where ξ is the form coefficient, C_{sph} the coefficient of sphere resistance depending on criterion R. Formula [2] recommended by the author, which agrees with other known data, appears to be, at sight, more correct than the dependence described by equation [1]. The values of the coefficients of particle resistance calculated by formula [2] proved to be only 10–15% higher than the coefficient of sphere resistance, using one and the same number R, while the application of formula [1] resulted in the lowering of the values by 1.5 to 2.5 times. In an editorial comment it is shown that the deductions of Khudyakov and the author lie within the limits of possible divergence in the results of the analysis of the experimental data. This was a consequence of insufficient accuracy of the experiment from the point of view of a well-defined and set principle for the resistance of particles moving in the flow. G. E. Khudyakov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4292. Hesky, H., Uniform sprinkling of reaction columns (in German), *Dechema-Monographien,* **29,** 354–363, 1957.

It is very important to wet the filler bodies in a reaction column uniformly so that the mixture at every cross section and at every point is the same composition. The resistance of a column against gas flow is least when the column is dry; it is greater the more it is wetted by sprinkling. If, now, the wetting (fluid flow) is not uniform, then the gas flow will be greater through the points where the column is dryer, and less where the column is wetter (i.e., the fluid flow greater). The problem was investigated to develop a swirl-type sprinkling nozzle which would produce an uniform distribution of liquid spray. A differential equation is developed to show the relation between rate of discharge, cone angle of spray, and uniformity of distribution.

A swirl nozzle construction is shown, based on the principles developed, in which the liquid is led to the mixing chamber through a number of guide passages arranged in two (or more) concentric circles; the inner passages have less slant toward the meridional plane than have the outer passages, and the innermost central passage is fully axial. From the mixing chamber the liquid issues through one single orifice. Diagrams show the even distribution of the spray, which is maintained even at varying liquid pressure, i.e., varying discharge rate. Spray cones of 90° angle have been attained, but larger cone angles are also possible.
K. J. DeJuhasz, Germany

4293. Debeauvais, F., Some aspects of disintegration of liquid jets in moving air: study of forced pulverization in an aerograph (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 359–366.

Continuation of former research, by using an air-liquid ratio of less than 3000, using a compressor-type aerosol generator termed an "aerograph." The velocity distribution was measured with a miniature pitot tube, with and without water jet, and only little difference was found, but the velocity distribution itself was not even within the cross section. Instantaneous photographs are shown. Conclusions: At air-liquid ratios higher than 5000 (e.g., in carburetors) the effect of surface tension is predominant and the effect of viscosity is low; the formula of Nukiyama and Tanasawa

was found to be valid. At air-liquid ratios below 5000 (as in the aerograph) the viscosity has great influence on the phenomenon of disintegration. K. J. DeJuhasz, Germany

4294. Debeauvais, F., Some aspects of disintegration of liquid jets in moving air: study of forced pulverization in an experimental carburetor (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 349–358.

Based on previous researches, mainly on Littaye (1942), atomization of liquid in a parallel stream of air is studied experimentally from the issuance of the jet from the nozzle until its complete disintegration into discrete drops of approximately spherical shape. A small wind tunnel of 8 cm × 8-cm cross section is used, with a glass nozzle of 1-mm diam. Air velocity was varied from 0 to 100 mps; liquid discharge was varied up to 0.5 cm^3/sec, giving a very lean mixture of air/liquid of the order of one million.

Velocity distribution in the cross section was found to be very even; velocity change and pressure change along the axis of the tunnel have been determined and charted. Three methods of observation were used: (1) a "semi-stroboscopic" visual observation (because the phenomenon is not periodic) for getting a general idea; (2) instantaneous photography using a flash of about 0.5 microsec duration, capable of separating drops of 5 micron diam; (3) ultra-rapid movie camera using double-flash illumination. Distilled water was used for liquid. The jet first forms a filament, which is spread out into a sheet, which in turn breaks up into droplets. Photographs illustrating these successive stages are shown. K. J. DeJuhasz, Germany

4295. Nanninga, N., Computation of the pressures on walls of corn and flour stores (in Dutch), *Ingenieur* **68**, 44, 190–194, Nov. 1956.

4296. Innes, W. E., Use of a parallel plate model in calculation of pore size distribution, *Analyt. Chem.* **29**, 7, 1069–1073, July 1957.

4297. Mikhalov, G., Hydrodynamic study of a steady two-dimensional potential flow of a liquid with free surface through a homogeneous rectangular dike taking account of capillarity (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 127–134.

An approximate determination of the flow, uniformly valid for arbitrary values of the capillarity, is presented. Explicit forms for the mapping from the velocity hodograph to the physical plane are given, with the circular segment corresponding to the free surface approximated by a straight line.

C. M. Ablow, USA

4298. Andersson, B. J., Studies on the circulation in organic systems with applications to indicator methods, *Kungl. tekn. Hogskol. Handl.* no. 114, 19 pp., 1957.

4299. Shcherbakov, G. V., Method of investigating deep pump wells according to the restoration rate of the face pressure after the termination of pumping from the wells (in Russian), *Neft. kh-vo.* no. 3, 32–37, 1956; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6779.

Geophysics, Meteorology, Oceanography

(See also Revs. 4141, 4142, 4143, 4180, 4221, 4271)

Book—4300. Lutkovskii, S. V., Ice formation on lakes, rivers, and seas (in Russian), Moscow, Acad. Sci. USSR, 1957, 119 pp.

This summary of contemporary knowledge in this specific field covers: Origin of crystals; Ice formation on lakes; Specific conditions for river ice formation–at surface and in water, frazil, anchor ice; Freezing and ice thickness; Ice phenomena at sea, particularities of polar ice, icebergs; Ice growth and deformations; Ice phenomena forecast. S. Kolupaila, USA

4301. Proudman, J., On the series that represent tides and surges in an estuary, *J. Fluid Mech.* **3**, 4, 411–417, Jan. 1958.

Paper gives explicit formula in the form of infinite series for the case of a progressive wave in an infinitely long estuary of uniform cross section. The problem is nonlinear in two aspects: (1) finite amplitude, (2) a permanent current on which the wave is superimposed. W. H. Munk, USA

4302. Townsend, A. A., Turbulent flow in a stably stratified atmosphere, *J. Fluid Mech.* **3**, 4, 361–372, Jan. 1958.

Fluctuations of velocity and temperature which occur in a turbulent flow in a stably-stratified atmosphere far from restraining boundaries are discussed using the equations for the turbulent intensity and for the mean-square-temperature fluctuation. From these an equation is derived for the flux Richardson number in terms of the ordinary Richardson number and some nondimensional ratios connected with the turbulent motion. It is shown that the interaction between the temperature and velocity fields imposes on the flux Richardson number an upper limit of 0.5, and on the ordinary Richardson number a limit of about 0.08. If these values are exceeded, no equilibrium value of the turbulent intensity can exist and a collapse of the turbulent motion would occur. The analysis applies strictly to a homogeneous nondeveloping flow. The predictions are compared with recent observations of stratified flows by C. I. H. Nichol.

From author's summary by A. M. Kuethe, USA

4303. Vasyukov, K. A., Analysis of local changes of pressure in conditions favoring the formation of cyclones in the troposphere (in Russian), *Tr. Tsentr. in-ta prognozov* **45**, 72, 3–58, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2062.

4304. Sakalia, L. I., Annual course of the coefficient of turbulence (in Russian), *Meteorol. i gidrologiya*, no. 2, 18–21, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2076.

By means of the study of the data of the meteorological observations of the agrometeorological station at Odessa, and also of the aerological observations a calculation was made of the annual course of the coefficient of turbulence k in the atmosphere at the earth's surface and in the boundary layers.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Lubrication; Bearings; Wear

(See also Revs. 3912, 4031, 4309)

4305. Krzywoblocki, M. Z. v., On the Reiner-Taylor-Saffman dilemma, *J. aero. Sci.* **24**, 915–916 (Readers' Forum), Dec. 1957.

The theoretical prediction of second-order effects in the motion of fluids was made by M. Reiner in 1945. Experiments gave support to Reiner's predictions, and suggested to him that centripetal pump effects may exist in gases as well. He then demonstrated by a series of carefully controlled experiments, employing precision equipment, that the centripetal pump action in non-Newtonian fluids can, in fact, be produced in air. This led Reiner to infer in a natural way that the behavior of air under the conditions of his experiment is not represented or embodied in the Navier-Stokes equation. Taylor-Saffman [AMR **11** (1958), Rev. 708], by referring to the Chapman-Enskog approximation for obtaining approximate

solution to the Boltzman equation, conclude that Reiner's interpretation of the results, as non-Newtonian, is not justified.

Author does not concur with this position by questioning the validity of the Chapman-Cowling approximation method. Following a detailed discussion concerning the possible domain of validity of the Navier-Stokes equation, author concludes that the position presented by Taylor-Saffman is not conclusive, and that the interpretation of the Reiner effect in gases remains an open problem.

Reiner is presently concluding experiments with liquids specifically designed to determine in a crucial manner whether the Taylor-Saffman explanation on the basis of geometrical and dynamical imperfections in apparatus is valid. Preliminary experimental results thus obtained indicated that the Reiner effect is present in liquids, and imperfections may be irrelevant to the centripetal action. These remain to be carefully checked before definite conclusions can be drawn. P. Lieber, Israel

4306. Wisander, D. W., Hady, W. F., and Johnson, R. L., Friction studies of various materials in liquid nitrogen, *NACA TN* 4211, 16 pp. + 1 table + 16 figs., Feb. 1958.

Friction data were obtained under conditions applicable to positive-displacement pumps (2300 fpm sliding velocity and 1000-gram load) with a 3/16-inch-radius hemisphere sliding on the flat surface of a rotating disk. Graphite-filled Teflon gave lower friction coefficient (0.15) and wear than other materials, including rolling-contact-bearing metals, mechanical-seal-type carbons, phenolic laminates, and a cermet. Other filled Teflon compositions also gave good results. Phenolic laminates gave relatively high friction (>0.5). From authors' summary

4307. Halton, J. H., Elliptical whirl of flooded journal bearings, *Proc. Camb. phil. Soc.* **54,** part 1, 119–127, Jan. 1958.

The equations governing bearing whirl are treated in a very general way and solutions are obtained for the case of the infinitely wide bearing and for the narrow bearing as governed by Ocvirk's approximation. Bearings are assumed to be perfectly aligned, fully filled with incompressible isoviscous lubricant, and the solutions obtained are applicable to unloaded or constant-loaded bearings with elastic, massive frictional suspensions. The results are in general agreement with experiment except for one important feature. The present theory predicts that the angular velocity of circular whirl should always equal $(K/M)^{1/2}$ where K is the elastic constant for the "free" cylinder suspension and M is the mass of the free cylinder. However most experimenters report that the angular velocity of circular whirl always approximates to one half of the velocity of shaft rotation.

F. T. Barwell, Scotland

4308. Miller, W. R., Walsh, T. J., and Slaymaker, R. R., Effect of capillary length-to-diameter ratio on grease viscosity, *Lubrication Engng.* **14,** 5, 216–220, May 1958.

Seven greases were tested in a capillary tube viscosimeter in order to study the effect of capillary length-to-diameter ratio on their apparent viscosity. All greases were tested at 75 F, and three were tested at 40 F. A change in apparent viscosity occurred in all greases for capillary length-to-diameter ratios of 250:1. Beyond this point there was little change in apparent viscosity, with the exception of grease E which exhibited a change to ratios of 1000:1. Reducing temperature increased the change in apparent viscosity for two given capillaries at a constant shear rate.

From authors' summary

4309. Gillette, C. R., Oil and grease lubrication of antifriction bearings, *Prod. Engng.* (Design Digest Issue) **28,** 15, C6–C7, Oct. 1957.

4310. Pomey, J., Lubricated friction under severe conditions I, II (in French), *Rev. Inst. fr. Petrole et Ann. Comb. liq.* **12,** 6, 754–780, June 1957; **12,** 7/8, 887–914, July/Aug. 1957.

Long miscellaneous paper reviews and discusses several questions about lubricated friction under the most severe speed and pressure conditions ("lubrication under extreme conditions"). Both thermal (cementation, nitruration) and chemical (phosphatation, sulphuration) previous treatments to avoid seizing of metal surfaces are considered, as well as addition of sulphurized or chlorinated products to lubricating oil.

Blok's calculation of the rise of temperature in contacting sliding cylinders is repeated in a shortened way. A similar calculation for the "4-ball (Boerlage) machine" is developed (a rotating ball compressed against 3 equal contacting fixed balls); final results (temperature) look rather dubious, owing to many admitted simplifications and hypothesis. However, their use in conducting and interpreting normal and some unusual tests in the "4-ball machine " is considered, taking into account the qualitative influence of several causes of discrepancies between theory and physical reality.

After some concluding remarks about the limiting boundaries (p, v) of various lubrication conditions, some results of wear tests on balls chemically treated in different ways and lubricating oils without or with additives are reported and discussed.

This paper gives a clear description of the many problems connected with lubrication under extreme conditions, from the several possible points of view. Its main interest consists in the analysis and discussion of seizing tests as conducted in the "4-ball machine." R. Giovannozzi, Italy

4311. Constantinescu, V. N., About a class of boundary-layer flow of viscous compressible fluid (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 294–305.

A highly condensed account of author's researches into gas lubrication, with 13 references to his own work. First part deals with case of no heat transfer and sketches method of solution when the relative velocity of the surfaces tends to zero and to infinity, and gives approximate method in other cases.

When there is heat transfer, it appears to be possible, after various assumptions have been made, to determine the distribution of temperatures.

No illustrations are given. There is confusion as to notation and some wrong equation numbering. J. C. Cooke, England

4312. Chen, J-S., Theory of conjugate surfaces of continuous sliding contact and its applications (in Chinese), *Chinese J. mech. Engng.* **4,** 2, 187–217, Dec. 1956.

4313. Davis, A. J., and Krok, T. V., Sleeve bearings; Part I: Development of a testing machine, Instn. Mech. Engr., Lond., Prepr., 10 pp.

A machine has been developed for the investigation of sleeve bearings operating in the transition range between full fluid and boundary lubrication. Results of some tests are given.

From authors' summary

4314. Davis, A. J., Sleeve bearings: Part II: Running-in characteristics, Instn. Mech. Engr. Lond., Prepr., 10 pp.

A series of bearings manufactured from two different materials and having various clearance and length-diameter ratios has been tested on journals having various types of surface finish, using the machine and experimental technique described in part I. The investigation was concerned mainly with the changes in performance which occur during running-in, and with the ultimate performance which is obtained, under conditions of thin film lubrication. Some tests have been made on the effect of a solid boundary lubricant (molybdenum disulphide).

From author's summary

Marine Engineering Problems

4315. Maruo, H., The theory of the wave resistance of a ship in a regular seaway, *Bull. Fac. Engng., Yokobama nat. Univ.* **6,** 21–32, Mar. 1957.

Author gives analytical expressions for resistance due to periodic motions of a vessel steaming against oblique regular waves. By linear approach, assuming small amplitudes of waves and oscillations, the force is expressed in terms of singularities creating the flow. No constraint of small beam-length ratio.

Resistance due to forced oscillations and to drifting force of waves generating these oscillations is combined in a single term whose sign is definitely positive, though contribution of the former may gain negative values. Influence of phase angle on the latter part is eliminated. Paper greatly surpasses earlier work of Haskind, which is not quoted [ZAHI Report 603, Moscow 1946]. The excellent, skillfully contracted analysis cannot prevent reviewer from objecting that: (1) doublet distribution μ on surface may well attain order equal to source distribution; (2) Lagally's formula for mean of oscillating force on a thick body not entirely submerged deserves modification in case of nonzero speed; (3) excess resistance increases to infinity for $\omega_0/x_0 = 1/4$.

More recent papers of author extending above theory are: (1) *Intern. Shipbuild. Progr.* 4/35 July 1957; (2) Soc. nav. Arch. Japan 60th Annivers. Series, **2,** Apr. 1957.

K. Eggers, Germany

4316. Shimanskii, Yu. A., Theory of the raising of a sunken vessel (in Russian), Sb. statey po sudostroeniyu. Leningrad, Sudpromgiz, 1954, 200–215; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1945.

Conditions are examined which determine the position of stable equilibrium of a sunken vessel when floating up in the process of being raised. The dynamic factors influencing the action of the vessel being floated up are not taken into account. An investigation is carried out on the transverse and longitudinal stability (to roll) of a ship with partly drained sections at the moment of its breaking away from the bottom, the transverse stability when the vessel is partly floated, when it breaks away from the bottom at one end but is still fully submerged; a method is proposed to determine the position of the vessel and its transverse stability when the floating end surfaces. Schemes for calculations are worked out, bound up with the determination of the position of the vessel and its stability (to roll) on being floated; in connection with this the whole process of floating is divided into four periods. The possibility is indicated of carrying out the floating of the ship in separate stages with the use of supplementary floating appliances (pontoons), suspended at the ends of the vessel.

S. N. Blagoveshchenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4317. Shimanskii, Yu. A., Conditions for the proper repair and finishing work on the hull of ship (in Russian), Sb. statei po sudostroeniyu, Leningrad, Sudpromgiz, 1954, 92–98; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1132.

Article was first published in 1944. It is shown that when repairing ships, either afloat or in dry dock, when it comes to replacing worn or damaged permanent bracing of the hull, and in the hull sections, forces are at work, conditioned by its longitudinal deflection, and residual stresses are set up in the hull, making it possible for them to react in an unfavorable way on the general longitudinal stability of the ship. Simple formulas are brought forward permitting the determination, by calculation, of the value of these stresses, the estimating in each specific case of the unfavorable influence exerted by the conditions of finishing or repair work of the ship on the stability of the hull, and the laying down of the line to be followed to change these conditions, in order to reduce their injurious influence on the general stability to acceptable limits.

N. N. Babaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4318. Ershov, N. F., Determination of the limiting load of the skin of a ship (in Russian), *Nauch. tr. Odessk in-ta inzh. mor. flota* no. 11, 41–51, 1954 (1955); *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1126.

A method is put forward for the determination of the load limit for the plating of a ship, both for the frame as well as the plates, with the stipulation that there should be present in the skin residual deformations, without investigation of the work of the skin in the zone of plastic deformations. The limiting transverse load without consolidation is determined by adjusting the magnitude of the bending moment in the dangerous section of beamplate, subjected to the action of a transverse load and tensile force, in consonance with the known solution [see P. F. Papkovich, "Structural mechanics of a ship," part II, Sudpromgiz, 1941], to the value of the bending moment limit in the presence of axial forces, giving rise to the limiting, without consolidation, condition of the material, when the stresses attain the limit of flux throughout the whole section. With the obtained formulas computations are made of the values of the axial forces, corresponding to the limiting, without consolidation, condition of the materials and the limiting transverse loads in relation to the given spacing and the thickness of the skin. Curves were constructed in accordance with the results of the obtained computations, permitting the direct determination of the limiting load, without consolidation, at the given spacing and thickness of the skin. As the calculations showed, when computing the limiting load, without consolidation, for the sheathing of the less sturdy types, such as timber and tanker craft and small ships plying in ice-laden waters, the influence of the axial force must of necessity be taken into account, whereas for the skin of ice-breakers the taking into account of this influence is not obligatory.

B. I. Slepov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4319. Bulakh, G. D., Calculation of stresses due to general bending of a ship without the use of reduction (in Russian), *Nauch. tr. Odessk. in-ta inzh. mor. flota* no. 11, 60–68, 1954 (1955); *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1123.

A new method is put forward for determining the stresses due to general bending of the ship, when recourse is not made to the generally known method of reduction of the joints of the plane of transverse section, entering into the components of the equivalent joist. For this purpose a preliminary graph is built to show the changes of the general bending moment as a function of the stresses, which enables one to follow the whole process of change of the stressed condition of the hull and to indicate at which values of the external moment there is loss of stability in this or that flexible joint. The process foresees the possibility, when calculating the general stability, of evaluating the influence of chain stresses in plates, if the latter are found to be sufficiently flexible. The building of the graph commences with the determination by the usual method of the moment of inertia of the equivalent joist (all joints are deemed to be rigid) and of the position of the neutral axis. The author, selecting the values of the stresses for the flexible joints of the deck and bottom of the ship according to Euler's formula, determines the magnitude of the bending moment at which the flexible joint of the deck or bottom loses stability, when the moment possesses the minimum value for Euler's stresses, and the size of the fibrous stresses of the rigid joints of the deck and bottom at the most distant parts from the neutral axis. The first stage showing the changes of the fibrous stresses of the rigid joints of the deck and bottom is built on the values

obtained on the graph for the bending moment and the fibrous stresses. In further work on construction of the graph account is taken of the weakening of the section due to the successive elimination from it of the joints which have lost their stability and to additional stresses in all the flexible and rigid joints which have not yet lost their stability. It is possible to judge, from a graph constructed in such a manner, the need for the strengthening or weakening of this or that joint. B. I. Slepov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4320. Shimanskii, Yu. A., Calculations of the stresses and deformation of the hull of a ship due to temperature (in Russian), Sb. statei po sudostroeniyu, Leningrad, Sudpromgiz, 1954, 84-91; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1125.

The contents of the author's work, published in 1940, are given on the subject of an approximate calculation of the stresses and deformations of the hull of a ship, formed in consequence of differences in temperature of its longitudinal joints. An assumption is introduced into the basis of the calculation, namely, that the cross section of the hull of the ship, when bending is in progress, remains a plane surface. A number of special cases of the distribution of temperature are investigated, and formulas are deduced for the deflection and the angle of inclination of the neutral axis. Detailed numerical examples of the calculation are furnished.

T. T. Khachaturyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4321. Korotkin, Ya. I., Stability of the bottom plates of a ship taking into account the influence of continuous crosspieces (in Russian), *Trudi Leningrad. Korabel'stroit. in-ta* no. 16, 11-20, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1128.

The problem is examined of the calculation of the influence of the bending of the plates of the crosspieces, and also the influence of the ribs for rigidity, fixed on the crosspieces, on the Euler loading of the bottom plates. The influence of the bending of the crosspieces is studied on the basis of investigation of the problem on the stability of the beamplate system, elastically fixed to the intermediate and end supports, corresponding to the places of union of the crosspieces to the bottom plates, losing stability along the cylindrical surface. The problem is solved by the method of angular deformations. A more significant influence of the Euler loading of the bottom plates, which it is essential to calculate, is shown to be the arrangement of the rigid ribs on the walls of the crosspieces. Calculations show that this factor of influence leads to an increase in the Euler loading of the bottom plates by more than two-fold. It is demonstrated that the rigid ribs fixed on the crosspieces in practice (without calculation) have a rigidity significantly in excess of their critical requirements, and their influence on the Euler loading of the bottom plates can be evaluated with the help of the formulas given in the article.

B. I. Slepov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4322. Shimanskii, Yu. A., Utilization of the experiment of operating ships on the basis of the general longitudinal stability of the hull (in Russian), Sb. statei po sudostroeniyu, Leningrad, Sudpromgiz, 1954, 115-120; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1129.

It is pointed out that an analysis of wrecked and other less damaged hulls of ships, which occur in the operation of ships in wartime, has shown that in all cases, without exception, the cause of these damages was due to the violation of the elementary requirements of existing rules and standards. In particular, the stability of the hull sections in the end portions of its length was not checked by corresponding calculations, and in the constructional designing of the hull in these portions grave errors were overlooked; the different discontinuous joints in the hull were constructionally incorrectly formed; in some ships the hull of the ship was proved to be very seriously weakened as the result of using an unusually small spacing between the rivets of the shaped elbows of the cross bulkheads; there was also a defective combination in the hull of different sorts of shipbuilding steels, and an inferior standard of construction and manufacture of welded hulls. On the basis of the above the conclusion is reached that the existing rules and standards for the evaluation of the general longitudinal stability of the hull are not only not discredited by the test of operating ships built according to these rules, but, on the contrary, this test has confirmed their pertinence in meeting requirements issuing from practical experience. In the author's opinion, it is essential, together with the organization measures directed to the removal of the possibility of repeating the mistakes, to work out rules for the construction of a ship's hull and to test again the principal ships under construction for bending and sagging, with the object of bringing out their structural qualities and the elimination of defects disclosed during the tests. N. N. Babaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4323. Matskevich, V. D., and Postnov, V. A., Standardization of local deformations due to welding of a ship's hull (in Russian), *Trudi Tsentr. n.-i. in-ta recb. flota* no. 31, 50-86, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1130.

It is assumed that when the deformations are small, when starting from a flat surface, the pointer of deflection w_0 is expressed for l between rigid members by the formula $w_0 = Bl^2$, where B is a constant value, depending on the technology of production. By analyzing the data of a large number of production investigations, tables were compiled for the final value of B. Calculations are furnished for the expected deformations: deflection and the shortening in the surface of the assembly of the rigid ribs, due to the yielding of the welded seams; angular deformations, appearing in consequence of irregular distribution of plastic deformations in relation to the thickness of the plate; sagging due to loss of stability during the welding of the assembly. It is supposed that the sagging deformation in the zone of the welded seam produces internal forces which, in relation to their action on the plating, may be examined as external tangential forces:

$$r_1 \sin 2\pi y/b, \text{ when } x = \pm 1/2\,a$$
$$r_2 \sin 2\pi x/a, \text{ when } y = \pm 1/2\,b$$

where a and b are the dimensions of the plates. The deflection is sought for in the form:

$$w = w_0 \cos(\pi x/a) \cos(\pi y/b)$$

The nonlinear equation of the joint deformations integrates accurately, upon which all the boundary conditions are satisfied on the assumption that the plate is freely open along all its four edges, safeguarding its rectilinearity and remaining in the surface of the plate. The equation of equilibrium is integrated by Bubnov's method, and the dependence of w_0 on the extent of the drawing together of the transverse and longitudinal edges is determined. An investigation is made of the influence of local deformations on the general stability of the hull, following the known methods [P. F. Papkovich, "Structural mechanics of the ship, Part II," Sudpromgiz, 1941]. Tables and graphs are given indicating the permissible values of local deformations for some types of ship construction.

Kh. M. Mushtari

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Letters to the Editor

4324. RE: AMR 10, Rev. 3344 (October 1957): Noseda, G., The discharge over a ... Weir; (bottom intake racks) (in Italian).

The title of the above review should have referred to Tyrolese weir instead of Tyrolose weir. The editors regret this error.

4325. RE: AMR 11, Rev. 213 (January): Marchi, E., Waves with a long period (in Italian):

The above abstract should have been signed "From the author's summary by P. FRANKE, Germany. The editors regret this error.

4326. Re: AMR 11, Review 2557 (July 1958): Abbett, R. W., edited by, American civil engineering practice, Vol. III.

The price of this volume is $25.00 and not $15.00. The editors regret this error.

Books Received for Review

BINDER, R. C., Advanced Fluid Mechanics, Vol. I, New York, Prentice-Hall, 1958, xii + 296 pp. $6.75.

BINDER, R. C., Advanced Fluid Mechanics, Vol. II, New York, Prentice-Hall, 1958, xii + 297 pp. $6.75.

BRONSTEIN, I. N., and SEMENDJAJEW, K. A., Tashchenbuch der Mathematik, 1958, Leipzig, B. G. Teubner, Verlagsgesellschaft, 1958, xii + 548 pp. DM 22. 50.

BROWN, J. G., edited by, Hydro-electric Engineering Practice, Vol. I: Civil Engineering, London, Blackie & Son, Ltd., 1958, xxx + 1189 pp. 9 pounds 9 shillings.

BROWN, J. G., edited by, Hydro-electric Engineering Practice, Vol. II: Mechanical and Electrical Engineering, London, Blackie & Son, Ltd., 1958, xxvi + 740 pp. 6 pounds 6 shillings.

BROWN, J. G., edited by, Hydro-electric Engineering Practice, Vol. III: Economics, Operation and Maintenance, London, Blackie & Son, Ltd., 1958, xxviii + 473 pp. 4 pounds 4 shillings.

CHURCHILL, R. V., Operational Mathematics, second edition, New York, McGraw-Hill, 1958, x + 337 pp. $7.00.

COSGRIFF, R. L., Nonlinear Control Systems, New York, McGraw-Hill, 1958, viii + 328 pp. $9.00.

DWIGHT, H. B., Mathematical Tables of Elementary and Some Higher Functions, second revised edition (first edition published by Dover 1941), New York, Dover Publications, 1958, vii + 220 pp. $1.75 (paperbound).

EVANS, R. H., and BENNETT, E. W., Pre-stressed Concrete, Theory and Design, New York, John Wiley & Sons, Inc., 1958, xv + 294 pp. $10.00.

FISCHER, H., and MANSUR, L. C., Conference on Extremely High Temperatures, New York, John Wiley & Sons, 1958, xii + 258 pp. $9.75.

HAMMOND, R., Dispersion of Materials, New York, Philosophical Library, 1958, x + 230 pp. $10.00.

HAMMOND, R., Separation and Purification of Materials, New York, Philosophical Library, 1958, x + 327 pp. $10.00.

HILL, T. H. W., Mathematics for the Layman, New York, Philosophical Library, 1958, 343 pp. $15.00.

JACOBSEN, L. S., and AYRE, R. S., Engineering Vibrations with Applications to Structures and Machinery, New York, McGraw-Hill, 1958. $10.00.

KECK, K. F., Zahnrad praxis, Vol. II: Schragzahnstirnrader, Degelrader, Munchen, Verlag R. Oldenbourg, 1958, 404 pp.

MASON, P., and WOOKEY, N., edited by, The Rheology of Elastomers, Proceedings of a Conference Organized by the British Society of Rheology, held at the British Rubber Producers Research Association, Welwyn Garden City, May 1957; New York, Pergamon Press, 1958, vii + 202 pp. $8.50.

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